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ART. XVII.—*On the great Lava-flood of the West; and on the structure and Age of the Cascade Mountains;* by JOSEPH LECONTE, Professor of Geology, University of California.

DURING the past summer, I made a geological tour through portions of central and eastern Oregon, the principal object of which was to examine the great lava-flood which covers this region, and more especially to study the structure and determine the age of the Cascade Mountains. In this tour I was accompanied and greatly assisted by Rev. Mr. Condon of the Dalles, a man widely known and greatly honored, no less for his disinterested courtesy than for his extensive knowledge of the geology of this portion of the State. Two years before, I went over nearly the same ground, and also extended my observations into Washington and British Columbia. The purpose of my last visit was to solve, if possible, some of the questions started in the first visit.

I. *The great Lava-flood.**

Extent.—As already stated in my paper on the "great features of the earth surface,"† this is probably the most extraordinary lava-flood in the world. Commencing in middle California as separate streams, in northern California it becomes a flood flowing over and completely mantling the smaller inequalities, and flowing around the greater inequalities of surface, while in northern Oregon and Washington it becomes an abso-

* I use the word *lava* here, and elsewhere in this paper, as synonymous with eruptive rocks.

† This Journal, vol. iv, p. 470.

lutely universal flood, beneath which the whole original face of the country, with its hills and dales, mountains and valleys, lies buried several thousand feet. It covers the greater portion of northern California and northwestern Nevada, nearly the whole of Oregon, Washington and Idaho, and runs far into Montana on the east and British Columbia on the north. Its eastern and northern limits are not well known, but its extent cannot be less than 200,000 to 300,000 square miles, i. e., greater than the whole area of France, or nearly double the area of California.

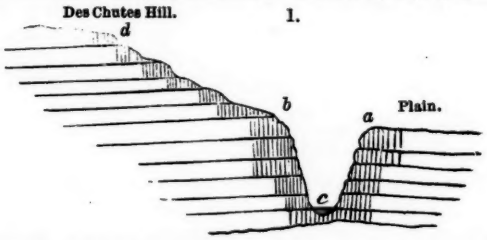
Source.—This immense mass of liquid matter was derived from streams which issued, as I believe, from *fissures;* some of them in the Coast Range, but mostly in the Cascade and Blue Mountain Ranges. The streams from these two latter sources especially flowed until they met and formed an almost universal sheet.

Thickness.—The greatest eruptive activity seems to have been in the region of the Cascade Range, and here therefore the flood seems to have reached its greatest depth. The area covered by the Cascade flows alone cannot be less than .00,000 square miles and the *extreme thickness is not less than* 3700 *feet.* The average thickness over the whole area is probably 2,000 feet. As this seems an extraordinary statement, we will briefly give the evidence on which it rests.

The Columbia River, in its way from the interior plains to the sea, cuts through the Cascade Range *nearly to its very base*; for in this region the river surface is not more than 100 feet above the sea level. In all this portion of its course, for 100 miles, the river runs in a gorge, the perpendicular cliffs of which give a magnificent section of the Cascade Range from top to bottom. At the cascades of the river, which are in the very axis of the range, the cliff peaks have, many of them, been measured by the U. S. engineers connected with the Pacific Railroad explorations. They vary from 2,500 to 3,800 feet above the river surface. For twenty miles above and below this point, the higher peaks rise to 2,000 feet. This grand section reveals the fact that this mighty range is composed wholly of lava, tier upon tier, from top to bottom. In one place only, viz: in the axis of the range, and that only for about two miles along the river, is the bottom of the lava reached by erosion. Here then, leaving off 100 feet of the underlying rock, which we will describe hereafter, we have a clear section of 3,700 feet of lava. And when we recollect that these peaks themselves are produced wholly by unequal erosion, as is plainly shown by the continuity of the planes of the lava layers from peak to peak, surely 4,000 feet is a moderate estimate for the original thickness of the lava flood at this part.

Nor is this thickness very exceptional for the lava of the Cascade Range. We have already said that the higher points of the lava cliffs of the Columbia cañon for near fifty miles are not less than 2,000 feet. But, in order to make this clearer, we will take another section which we examined, at some distance both from the axis of the range and from the Columbia River, viz: the *Des Chutes River section.*

The Des Chutes River is a large tributary of the Columbia, which, rising in southern Oregon, flows northward, parallel to the Cascade Range on the east side and at a distance from its axis of at least fifty miles. The region lying between the crest of the Cascade and the Des Chutes River is mountainous; but this mountainous region stops suddenly at the river, and beyond stretches, as far as the eye can reach, a nearly level lava-covered plain. Right along the line of contact between the mountain and the plain, the river has cut for itself, for more than 100 miles, a deep, extremely narrow gorge (fig. 1, *a*, *b*, *c*)



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with nearly perpendicular walls 1,000 feet high, formed wholly of beautifully columnar basalt, arranged tier upon tier, from bottom to top, the hardest and most beautifully columnar of all being in *the bed of the river*, *c*. Back from the edge of this precipice, on the east side, *a*, runs the plains, but on the west side, *b*, at the point examined by me—the upper bridge—the ground continues to rise with a gentler slope about 1,000 feet more, to the top of Des Chutes hill, *d*. Throughout the whole height, from the river bed to the top of Des Chutes hill, the edges of lava layers outcrop. I do not know the precise height of this hill above the river, but it cannot be less than 2,000 feet. I believe it is nearer 3,000 feet. Here then we have again, at a point 50 miles distant from the axis of the range and 30 miles from the Columbia River, a clear section of basaltic lava 2,000 to 3,000 feet thick, and *the bottom not yet reached.*

Beyond the Des Chutes, a nearly level lava plain, covered only with northern drift, stretches away eastward for 30 or 40 miles. This plain is intersected in all directions with deep, narrow stream-gorges, which do not reach the bottom of the

lava. Over the whole plain the lava cannot be less than 1,000 feet thick. Beyond the Des Chutes plains and separated from them by a lava ridge, stretches, for twenty miles more, to the base of the Blue Mountains, the region drained by the tributaries of the John Day River. Here the flows from the Cascades meet and mingle with those from the Blue Mountains, and both with *local* fissure eruptions. The lava in this region is less thick, only about 600 to 700 feet; and being underlaid by the remarkable fossiliferous Miocene lake deposit of the John Day Valley, erosion has cut through the lava cap into the soft strata beneath, giving rise to that extraordinary jumble of steep round hills, some capped with lava and some uncapped, called in the expressive vernacular, "the devil's potatoe patch." Imagine a patch twenty miles square, thickly covered with potatoe hills 1,000 feet high, and we have some idea of the extraordinary appearance of this region, as seen from the dividing ridge mentioned above.

Beyond this region I have not followed the lava flood; but others have traced it over a large part of the basin of the Columbia and especially of the Snake River. Clarence King traced it for 300 miles along the Snake River, where it is 700 feet thick.

II. *Structure of the Cascade Mountains.*

The Cascade Mountains, in the region of the Columbia River, with the exception of a very small portion at its very base and in its axis, is composed wholly of lava layers piled one atop another to a height of nearly 4,000 feet. Through this immense mass of lava, the river, whether in the form of ice-stream or water-stream, or both, has cut its way for 100 miles nearly to the sea-level, forming a cañon of unsurpassed magnificence. At the cascades of the river, which is in the very axis of the range, the base of the lava has been reached for a little distance, and *the original surface upon which the lava was outpoured is revealed.* Examination of the sub-lava material fixes, I think, with more certainty than has yet been done, the date of the Cascade lava-flood, and, therefore, the age of the Cascade Mountains. This point is so important, that I must give the evidence in some detail.

In August, 1871, under the guidance of Mr. Condon, I first examined the magnificent section of the Cascade Mountains made by the Columbia River at this point. The navigation of the river is obstructed here by a succession of rapids (called the Cascades), by which it falls about 50 feet in three miles. The upper and lower steamboat landings are connected by a short railroad on the northern or Washington side. The river current washes strongly against the south wall of the cañon,

forming a perpendicular cliff on that side. The point first visited by us was nearly opposite the lower steamboat landing. The section here revealed is of the extremest interest. In figs. 2 and 3 I give rude sketches of the face of the cliff (fig. 2) and

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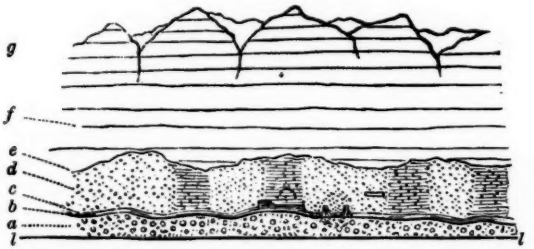

of a section at right angles to the face (fig. 3). These sketches make no attempt at accuracy in form or proportion. They are

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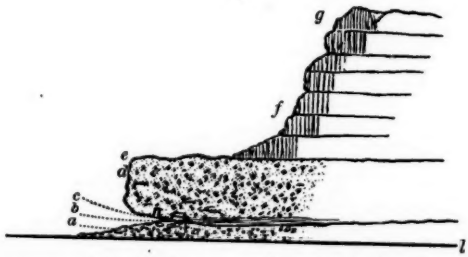


merely diagrams intended to render the following description more easily intelligible.

1. Along the water's edge, *l l*, and upward about 15 feet, we found a very coarse conglomerate (*a*) of rounded porphyritic pebbles and boulders of all sizes up to five or six feet in diameter, cohering by an imperfectly lithified earthy paste.

2. The conglomerate, *a*, was limited above by a very distinct irregular dark line, *b*, traceable for a mile or more along the river, which had all the characters of a dirt-bed or old ground surface. On this ground surface were found in an erect position two silicified stumps, with their roots spread out and penetrating the boulder material, *a*, beneath, and therefore evidently *in situ*. One of these is at least two feet in diameter, and its spreading roots could be traced over an area of 20 feet diameter. The roots of the other and smaller one was traceable four or five feet. Besides these two, there were three other vertical trunks in the overhanging cliff, the roots of which I suppose had been washed away by the river at high water.

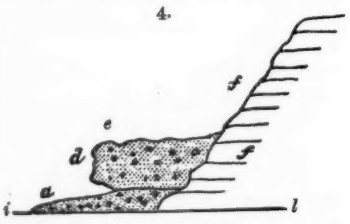
I have indicated these also in the figures. *The dark line, b, was certainly, therefore, an old forest-ground surface.*

3. Resting directly on this ground surface, and therefore enclosing the erect stumps, was a layer of stratified sandstone, *c*, two or three feet thick, filled with beautiful *impressions of leaves* of several kinds of forest trees, possibly of the very trees about whose silicified bases they are found. This layer is not continuous like the ground surface on which it rests.

4. Above this stratified leaf-bearing layer rests a coarse conglomerate, *d*, 100 feet thick, similar to the conglomerate *a*, but less coarse, and differing in being coarsely and irregularly stratified in places, *like modified drift;* in fact, undistinguishable from much of what is called northern drift except that it is partially cemented. Scattered about in the lower part of the conglomerate, *d*, and in the stratified sandstone, *c*, and sometimes lying on the dirt-bed, *b*, are fragments of trunks and branches of oaks and conifers, in a silicified or lignitized condition. They are evidently *silicified drift-wood.*

5. Above the conglomerate surface, *e*, and a little back from the river, rise the layers of lava, mostly columnar basalt, one above another, to a height, at this point, of 3,300 feet.

Such is a brief but accurate description of the cliff exposed by the Columbia River at the Cascades. My interpretation of these facts was then, as it is now, that the conglomerate *underlies* the lava, and, therefore, that the leaf-bed determines approximatively the age of the Cascade Range. But, as the actual contact of the basalt and the conglomerate was not then seen, subsequent reflection raised a slight doubt in my mind whether the conglomerate, instead of underlying, and therefore preceding the lava, may not be, in fact, a *subsequent river drift-deposit*—a bluff deposit—*overlying* the basalt and concealing the lower portion of its face, as shown in the diagram, fig. 4. Which of these diagrams (fig. 3 or fig. 4) represent the true relation of the basalt and conglomerate? Before publishing anything on the subject, therefore, I determined first to settle this point definitely.



With this object I revisited the locality in August last: and after confirming my previous observations and collecting a number of fine leaf impressions and fragments of silicified wood, I went up the stream-beds of three of the creeks which run into the Columbia River at this point; one of them, Rock Creek, from the north, and two, Tanner's Creek and Deadman's

Creek, from the south. As these streams run at right angles to the course of the main river, they give *actual* sections somewhat similar to the *ideal* section, fig. 3. Moreover, as the stream-beds rise rapidly as we go up stream, I hoped to find in the stream-beds the actual contact of the basalt with the conglomerate. As we shall see, my hopes were completely realized.

The creek first ascended was Rock Creek. It runs in from the Washington side, near the upper steamboat landing. We had not gone far up the stream before we found the conglomerate, already described, forming the bed and cliffs of the stream. Petrified driftwood was found in abundance sticking in the conglomerate, and washed out and strewed in the course of the stream, thus becoming drift a second time. Some of these drifted fragments were of enormous size, trunks four feet in diameter, five to six feet long and many tons weight. A little farther up the gorge the stream falls perpendicularly about 150 feet, over the upper and more firmly cemented portion of the conglomerate, upon the softer portion of the same beneath. On one side of the ravine, just below the fall, is exposed an admirable section, showing the *basalt resting directly on the conglomerate.* In fig. 5 I give a rough sketch of this section, made on the spot. The perpendicular height of the section is about 200 feet.

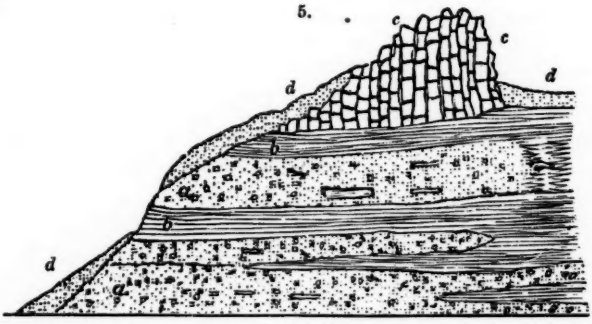


FIG. 5. *Cliff on Rock Creek.*—*a a*, pebble-conglomerate containing silicified driftwood; *b b*, stratified sands and clays; *c c*, irregularly columnar basalt; *d d*, superficial uncemented drift.

On the south or Oregon side, as already stated, we ascended two streams, but the most interesting was Tanner's Creek. This stream, for about three miles of its lower course, runs in a magnificent gorge, composed of conglomerate cliffs capped with towering summits of basalt. For some time the contact of these was not visible, being concealed by debris. But as the stream-bed rises the contact was approached, and finally

reached about three miles from the river. At this point, the lower and deeper gorge is blocked by a perpendicular wall of basalt, over which the stream precipitates itself as a fall 250–300 feet high The gorge, the cliffs with their summits towering 3000 feet or more, the perpendicular basaltic wall, and the fall with its cloud of spray, the fresh greenness of ferns contrasted with the rich purple of rocks, together form one of the loveliest scenes I have ever looked upon. From the top of the falls runs back a less deep gorge, formed wholly of basalt. The same is true of all the streams which run into the Columbia River in this axial region of the Cascade Range: they run in lava gorges in the upper portion of their course, then fall over a perpendicular basaltic cliff on to the conglomerate beneath, and then finish their course in this latter rock. The verticality of the fall is evidently the result of the more rapid wearing of the softer underlying conglomerate, and is, therefore, itself a convincing proof of this relative position. But we are not left to inference on this point, for, in every stream-bed ascended, but especially in that of Tanner's Creek, *the actual contact was distinctly seen.* Evidently then fig. 3 represents truly the relation of the lava to the conglomerate.

After returning from the examination of Tanner's Creek, we found still another point where the junction is exposed by the Columbia River itself. Since the Columbia River shows the conglomerate on its south bank only for about two miles, it is evident that if the conglomerate underlies the lava and is exposed only by erosion, the point of junction must be reached by ascending the stream; and on the Oregon side, where the river washes against steep cliffs, ought to be visible. Walking up the abandoned railroad on this side, we found at *Tooth Bridge* what we sought. Here a perpendicular cliff of magnificently columnar basalt comes down directly into deep water of the river. At low water, i. e., in late summer, when we visited it, about three feet of the cliff next the water is composed of conglomerate, *a a*, fig. 6, and the long, slender, gently curved and very perfect basaltic columns, *b b*, are seen to *rest directly on the conglomerate.*

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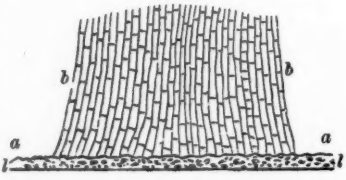


Everywhere the general character of the conglomerate was found the same. Everywhere it is composed of rounded porphyritic pebbles and boulders of all sizes, in a more or less cemented earthy paste. In many places it was affected with irregular stratification, and in such cases it nearly always con-

tained petrified drift wood. But erect stumps and leaf impressions, though diligently searched for, were found only at the locality first mentioned.

There is still another fact observed which has an important bearing upon the age of the lava-flow. Going up Tanner's Creek, the rising stream-bed reaches the upper surface of the conglomerate first about two miles from the main river. From this point, although the stream-bed continues to rise quite rapidly, the surface of the conglomerate again rises far more rapidly until it reaches a height of 200 *feet above the stream*, and then comes down again to the stream at the falls, where the contact is most clear. Again, at the point first examined (fig. 2), the upper surface of the conglomerate is 120 feet or more above the river, while it comes down to the water's edge at Tooth Bridge (fig. 6), a mile or two up the river, where the water surface is certainly but a few feet higher than at the lower point. I saw no evidence whatever of lifting or folding. It seems almost certain that the conglomerate surface upon which the lava was outpoured was a hilly land surface, made so by extensive erosion--*a second old ground surface.*

There can be no doubt, then, that the conglomerate really underlies the basalt for several miles from the river on either side. The line *b*, fig. 2 and 3, therefore marks an old forest-ground surface which antedates the Cascade lava-flow, and the silicified stumps are those of trees which grew on this ancient forest ground, and the leaves are leaves which fell possibly from these very trees, certainly from contemporaneous trees.

The order of events, as I conceive them, was briefly as follows: 1. The region of the Columbia River was a forest, probably a valley, overgrown with conifers and oaks. The subsoil of this forest was a coarse boulder drift. 2. By excess of water, either by floods or changes of level, the trees were killed, their leaves shed and buried in mud, and their trunks rotted to stumps. 3. Tumultuous and rapid deposit of coarse drift containing drift wood covered up the forest ground and the still remaining stumps, one hundred, perhaps several hundred feet deep. 4. The surface thus formed was eroded into hills and dales. 5. Then followed the outburst of lava in successive flows, perhaps for a long period of time, and the silicification of the wood and the cementation of the drift by the percolation of hot alkaline waters containing silica, as happens so commonly in sub-lava drifts. 6. Finally followed the process of erosion, by which the present stream-channels, whether main or tributary, have been cut to their present enormous depth.

In this last process of erosion the main river progressed more rapidly than the tributaries, and these latter, therefore, ran into the river on either side by foaming cascades, until the river

had cut down into the underlying conglomerate. Then they commenced to work back as perpendicular falls, until they reached their present position. *The cascades of the Columbia River; as well as the perpendicular falls at the head of the deep side-cañons of the tributaries, have all been formed and their places determined by the cutting of these streams through the harder basalt into the softer underlying conglomerate.*

III. *Age of the Cascade Range.*

There has been hitherto much doubt as to the age of the Cascade Range. The Coast and Sierra Ranges, so distinct in middle California, become in northern California and southern Oregon blended and undistinguishable. In northern Oregon and in Washington, the two ranges become again quite distinct, the eastern and larger one being here called the Cascade Range. Orographic evidence therefore seem to indicate that the Cascades are a continuation of the Sierras and formed at the same time. But Whitney has shown * on paleontological evidence that, while the Sierras were formed at the end of the Jurassic, the Cascades in northern California have certainly been much disturbed and to some degree at least elevated, since the Cretaceous. Farther north, the stratified rocks of the Cascade Range are so deeply buried beneath the lava-flood, that it has been impossible hitherto to find stratigraphical or paleontological evidence of the age of the range. This evidence is, I believe, now for the first time furnished by my examination of the sections made by the Columbia River and its tributaries at the Cascades. *The sub-lava conglomerate, with its leaf-bed, furnishes the means of determining the probable age of the lava-flood, and, therefore, of the great mass of the Cascade Range.*

My first conclusions on this subject, in 1871, were, I now believe, erroneous. The fact that the lava flows of California, on the southern skirts of the great Cascade lava-flood, and some of the flows in the John Day Valley, on its extreme eastern skirts, are *underlaid by the latest Pliocene;* and the additional fact of the great resemblance of the sub-lava conglomerate of the Columbia River to the cemented sub-lava drift-gravels of California, led me, very naturally, but perhaps too hastily, to conclude that the great lava-flood took place and the Cascade Range was built up during the Post-Tertiary period; and I stated this as my view in my paper, "On the great features of the earth surface" † I now acknowledge my error. The paleontological evidence is the only certain one, and this is unmistakeably in favor of a greater age. I sent the box of leaves and petrified wood gathered from the leaf-bearing stra-

* See Geol. Surv. of Cal., vol. 1, p. 320 and seq.
† This Journal, vol. iv, p. 470.

tum, *c*, fig. 2 and 3, to Prof. Leo Lesquereux for examination. According to this high authority, they consist of leaves of two species of oak and one of conifer, and wood of oak and conifer. "The species," he writes me, "mark undoubtedly *Miocene or uppermost Eocene*, more probably the former."* Therefore I conclude the leaf-bearing stratum, *c*, fig. 2, is *certainly Tertiary and probably Miocene*; and, therefore, the lava flood occurred or *began* to occur during or after the Miocene. And since the upper surface of the conglomerate is itself an *eroded* land surface (p. 175), which erosion took place after the period of the leaf-bed, the lava-flood occurred more probably *after* the Miocene, i. e., *coincidently with the formation of the Coast chain.* I said "*began* to occur," for the process of up-building probably continued by successive fissure-flows, building higher and higher and extending farther and farther, until the Post-Tertiary; so that the skirts in John Day Valley and in California are newer than the lower part of the lava of the central region. When the fissure eruptions had finally ceased, the work was taken up by volcanoes, which have continued it nearly or quite up to the present epoch.

The Cascade Range throughout the whole region of the lava-flood, i. e., for at least 700 miles, is not more than an average of 5,000 feet high, although some volcanic peaks rise 11,300 (Mt. Hood), and even 14,400 feet (Mt. Shasta and Mt. Rainier). Now we have just seen that, of this 5,000 feet, nearly 4,000 feet consists of lava outpoured since the Miocene; and, moreover, that this lava extends in great thickness over a breadth of 100 miles. Evidently then the great bulk of this range is of late Tertiary origin. But it is not probable that the Cascade Range was born or first commenced to exist at this time. It is almost certain that it already existed as a low ridge of granite and slate like the Sierras, continuous with the latter and of the same age. The proof of this has not indeed been yet found in the middle Cascade region nor on the eastern flanks, for these parts are too deeply covered with lava. But on the western and especially on the southern borders of the great flood, where the lava thins out, first, occasional peaks of slate and granite appear as islands above the flood-level, and finally the flood itself dwindles into streams flowing about the bases of granite and auriferous slate hills similar to those characterizing the Sierra Range. It is true, the sections made by the Columbia River and its tributaries examined by me showed no slate or granite beneath the lava, but only Miocene conglomerate; and this conglomerate is made up, not of slate or granite boulders, showing the existence before the lava flood

* A description of these leaves will appear in the forthcoming volume on Fossil Botany of the Geol. Survey of California.

of slate or granite hills in the vicinity, but only of porphyry or porphyritic lava boulders; nevertheless, I think diligent search will yet find the evidences of slate and granite beneath the lava.* If the question is again asked, What then is the age of the Cascade Range and to what system does it belong? I answer: Like most mountain ranges, it was not formed at once. It probably first commenced as a continuation of the Sierra Range, and at the same time, viz: the end of the Jurassic; and this part belongs to the Sierra system. But its great bulk was formed at the end of the Miocene coincidently with the Coast Range; and this part may be said to belong, *so far as age is concerned*, to the Coast Range system.

IV. *Theory of the ejection of the lava-flood and of the formation of the Cascade Mountains.*

Over the surface of the lava-flood, especially along the crests of the Cascade Range, are scattered a number of extinct volcanic cones. From the Des Chutes plains is obtained a magnificent view of this range, from the Three Sisters on the south to Mt. Rainier on the north, a distance of over 200 miles. Along this extent are ten or twelve conspicuous snow-clad cones; many other smaller ones probably exist. Are these, then, the fountains from which flowed the great lava-flood? Has all this immense mass of fluid matter been ejected by the force of steam generated by the contact of percolating meteoric waters with incandescent subterranean fluid masses! It seems to me incredible: the effect is out of all proportion to the cause. It is only necessary to state the proposition in order to see its absurdity. Besides, the lava of the Columbia and Des Chutes Rivers is nearly all *perfectly solid*, entirely free from those vesicles so universal in lavas ejected by steam from craters. Only in the uppermost parts was there found any evidence in the structure of the lava of true volcanic action—any of the *boursouflée* condition so characteristic of true volcanic ejections. It is clearly impossible to account for the outflowing of such great floods of liquid matter except by more general causes affecting the whole earth—except by the action of those grand agencies by which mountain chains themselves are formed.

I have already, in a previous paper,† maintained that the interior contraction of the earth determines irresistible horizon-

* Newberry speaks of the cliffs of the Columbia River gorge (P. R. R. Surv., VI; Geology, p. 57) as composed of lava and *slate*. I have never seen anything but lava. Just above the Cascades, on both sides of the river, are seen slaty-looking mountains. I myself, at one time, thought they were slate. They are in fact phonolite. In the John Day Valley, indeed, I saw genuine slate hills with quartz veins, exposed by the erosion of the lava-flood; but these belong evidently to the Blue Mountains, not the Cascade Mountain system.

† This Journal, vol. iv, p. 345.

tal pressure of the crust on itself. I have also shown that mountain chains are the lines along which yielding to this pressure takes place; also that the yielding usually occurs along marginal sea-bottoms, giving rise to coast chains; and the reason why it occurs along these lines. I think, therefore, it will be now generally admitted that mountain ranges (Dana's Synclinoria) are certainly formed by a mashing together horizontally and an up-swelling vertically of lines of thick sediments along marginal sea-bottoms. Now in this mashing together, with foldings and consequent fissurings of the strata, it is easy to see that any sub-mountain liquid matter, whether preëxisting, or (as I think more probable) locally formed by the very act of crushing, *must be squeezed out.* It is in this way that I account for the great lava-flood of the Cascade and Blue Mountains. *The liquid matter has been squeezed out by the same force which elevated the mountain ranges;* by enormous horizontal pressure, determined by the interior contraction of the whole earth. Afterward, steam generated by meteoric waters percolating through the still hot erupted mass gave rise to volcanoes, which carried on the up-building process.

Thus much I have maintained in my previous paper. But Dana has recently * pointed an *inverse relation* between the amount of mountain mashings and foldings on the one hand and the amount of fissurings and fissure-eruptions on the other. This I believe to be a true principle. I wish, therefore, to illustrate and explain it.

Mountain ranges are *first* formed as already explained. But the ranges thus first formed, usually become *afterward* lines of *successive* elevation by lateral pressure. A mountain range, first *born of the sea*, continues to grow, more or less paroxysmally, by the same force which originally formed it. But there is this difference between the first formation and the subsequent increase. The first yielding of the soft sea-bottom sediments is comparatively quiet, with *little resistance*, and, therefore, produces *little heat* by the transformation of mechanical energy: it is a *gradual*, quiet mashing together, with folding of the strata and up-swelling of the surface into a mountain range, and the *metamorphism*, but *not fusion*, of the strata; while, on the contrary, the subsequent yielding of the already hardened land-surface takes place only after much resistance, and, therefore, with *much heat*, even to *fusion* of the strata, and also *paroxysmally*, with the fissuring of the strata and the *out-squeezing* of the sub-mountain liquid. In the first case, there is an actual elevation, by up-swelling or uplifting of the stratified surface to the whole extent of the height of the mountain: while in the second case, the increase of height is not so much by uplifting of

* Results of Earth's Contraction—part 4, Igneous Ejections. This Journal, vol. vi, p. 113.

the stratified surface, as by *up-building on* this surface, by the out-squeezing of liquid matter. In either case, however, whether by uplifting or by up-building, the actual increase of height would be precisely the same, being determined by the amount of lateral crushing.

Of course, these two modes of mountain-making may be combined in various proportions. We will now illustrate by examples.

The *Appalachian* chain was first formed and nearly completed at the end of the *Coal period*, by mashing, folding and up-swelling only, while its second but trifling increase at the end of the Jurassic was attended with fissure eruptions of considerable extent. The *Sierra Range* was first formed at the *end of the Jurassic*, by mashing together and up-swelling only; while its subsequent slight increase at the *end of the Tertiary* was attended with great fissure-eruptions. Similarly the *Coast Range* was formed by crushing together and up-swelling of its sediments at the *end of the Miocene*, while its great fissure eruptions did not take place until the *end of the Pliocene* or later. So, also, the Cascade Range was first born of the sea by horizontal mashing and vertical swelling, probably at the end of the Jurassic, though only as a low range, continuing the Sierra northward; its great subsequent increase took place at the end of the *Miocene*, by the outpouring of the great lava flood. Thus the Appalachian, the Sierra and the Coast Ranges were formed almost fully grown by the first method, while the Cascade Range was formed almost wholly by the second process. There are also of course some mountain ranges which are formed wholly by the first process, i. e., by successive upliftings without any eruptions at all.

The view which I have presented above in its main features is equally tenable, whether we regard the sub-mountain liquid as *locally formed* by the transformation of mechanical energy into heat, as maintained by Mallet and believed by me, or whether we regard it as a remnant of the *original sub-crust fire-sea* of Dana.

[To be continued.]

ART. XVIII.—*Analytical Notices;* by SAMUEL P. SADTLER, Ph.D., Prof. of Chemistry, etc., Pennsylvania College, Pa.

IN the number of this Journal for Feb., 1873, Dr. Wolcott Gibbs gives some miscellaneous analytical notices, and, among other things, speaks of a form of "ring-burner," which he commends to the attention of chemists generally as a useful piece of apparatus. I have had occasion within the last month to use

this burner frequently in my laboratory, and have some few analytical results obtained by its use, which may be of general interest to working chemists.

My first use of the burner, however, dates back to the fall of 1869, when I was working in Dr. Gibbs' laboratory, on the double nitrites of cobalt and the alkali metals. I then used it constantly in determining the double sulphates of cobalt and potash or soda, and afterward the simple cobaltic sulphate. To my paper on these nitrites* I appended a few analytical notices, in which I spoke of the advantage of these methods of determination. One of my students having recently the determination of strontia to make, as a part of his analytical course, I had him determine it as strontic sulphate by the aid of the "ring-burner," and the results were so good, that I had the following series of experiments made to test the question of its applicability to sulphate determinations in several other cases.

The sulphates of the alkaline earths, barium, strontium, and calcium, are such stable compounds, and capable of standing such a high heat without decomposition, that they strike one at once as very suitable forms for the determination of these elements by evaporation with excess of sulphuric acid, in cases where the method by precipitation is not used. Accordingly, we find that the determination as sulphates by evaporation, of these three, is given by Fresenius, although not strongly recommended. Wöhler, in his "Mineral-Analyse,"† does recommend the determination of strontia and lime as sulphates. However, the evaporation of the excess of sulphuric acid over the ordinary forms of Bunsen-burner is so precarious an operation, as to effectually shut out these methods, except in case of necessity. With the "ring-burner," the evaporation of the excess of sulphuric acid is as safe as the evaporation of so much water over the water-bath.

Baryta.—Any of the compounds of baryta with volatile acids can, as Fresenius states, be determined as sulphate by evaporation with excess of sulphuric acid, and with the "ring-burner" rapidly and safely. I did not, however, make any quantitative determinations here, as the determination as sulphate by precipitation is so perfectly reliable and is generally applicable.

Strontia.—Here the determination as sulphate by precipitation is acknowledged to be of only tolerable accuracy, on account of the necessity of introducing the digestion with alcohol, and the subsequent washing with the same. The determination of sulphate by evaporation therefore, if accurate, would be of considerable importance. The results of some tests made by Mr. G. S. Eyster on this subject are as follows:

* This Journal, March, 1870. † Mineral Analyses, 161, pp. 14 and 19.

A lot of crystallized strontic nitrate was taken, powdered, and dried at 100°.

·7345 grms.	nitrate gave	·6348 grms.	sulphate	=41·21 pr. ct.	Sr.
·9840 "	" "	·8505 "	"	=41·21 pr. ct.	Sr.

A second lot was re-crystallized, and large crystals were taken and dried between filter paper only.

·3007 grms.	nitrate gave	·2594 grms.	sulphate	=41·13 pr. ct.	Sr.
·3641 "	" "	·3133 "	"	=41·03 pr. ct.	Sr.

A third lot was then carefully dried between 100°–103°.

·3318 grms.	nitrate gave	·2878 grms.	sulphate	=41·36 pr. ct.	Sr.
·3184 "	" "	·2758 "	"	=41·30 pr. ct.	Sr.

The theoretical amount of Sr in $Sr(No_3)_2$ is 41·37 per cent. These results show very much greater accuracy than the determination of sulphate by precipitation, and there is no comparison as to the ease of manipulation and the rapidity with which the determination can be made.

Lime.—Here the determination as sulphate by precipitation is rarely used. as it is open to exactly the same objections as the process with strontia. However, we can precipitate lime as oxalate, and then weigh it as carbonate, after gentle ignition; or, if the quantity be not too large, as caustic, after lengthened exposure to the blast-lamp, and the results are generally accurate.

However, it struck me that the sulphate determinations by evaporation were so accurate and so rapidly executed, that, instead of repeatedly igniting the oxalate with a piece of ammonic carbonate until a constant weight was obtained, we could convert the oxalate into sulphate, and run it down to dryness with the "ring-burner," with a great saving of time and labor. To test this, the following series of determinations with calcic oxalate was made by Mr. Edgar F. Smith at my request.

One lot of oxalate was prepared in the usual manner, washed on a filter and dried between 100°–105°.

·1860 grms.	oxalate gave	·1725 grms.	sulphate	=27·28 pr. ct.	Ca.
·2083 "	" "	·1939 "	"	=27·38 pr. ct.	"
·5013 "	" "	·4659 "	"	=27·33 pr. ct.	"
·1944 "	" "	·1808 "	"	=27·35 pr. ct.	"
·8097 "	" "	·7517 "	"	=27·31 pr. ct.	"

Another preparation of oxalate was made and washed as before, and dried at 110°. Fresenius says that the oxalate does not part with its water until heated to 205°, but has the invariable composition $(C_2O_4)Ca+H_2O$. The results show, however, that it begins to lose water already at 110°.

·2195 grms.	oxalate gave	·2051 grms.	sulphate	=27·48 pr. ct.	Ca.
·2432 "	" "	·2272 "	"	=27·48 pr. ct.	"

A larger quantity was then precipitated and washed by decantation with boiling water, until, according to Bunsen's tables, the impurities remaining were reduced to $\frac{1}{1000}$ in volume.

·7462	grms.	oxalate	gave	·6950	grms. sulphate	=27·39 pr. ct. Ca.
·7127	"	"	"	·6628	" "	=27·35 pr. ct. "
·7592	"	"	"	·7073	" "	=27·40 pr. ct. "
·8208	"	"	"	·7656	" "	=27·43 pr. ct. "

The theoretical per cent of Ca in $C_2O_4(Ca)+H_2O$ is 27·40.

In some of this last preparation, two determinations of the amount of Ca were made by ignition over the blast-lamp and weighing as caustic lime.

·1207	grms.	oxalate	gave	·0463	grms. CaO	=27·40 pr. ct. Ca.
·1520	"	"	"	·0584	" "	=27·44 pr. ct. "

Finally, two portions of perfectly pure calcic carbonate, from a crystallized piece of calcite, that had been previously analyzed, and the composition of which was therefore known, were taken. After the precipitation of the lime as oxalate and drying on the filter, it was put in a weighed platinum crucible and the filter ash then added. The whole was then run down as sulphate with slight excess of sulphuric acid, with the aid of the "ring-burner." Only one analysis is given, as the other was spoiled in filtering the oxalate.

·9723 grms. $CaCo_3$ gave 1·3058 grms. sulphate =39·50 pr. ct. Ca.
39·50 per cent Ca corresponds to 55·30 per cent CaO.

Fresenius gives as the composition of "air dried $CaCO_3$," 55·51 per cent CaO, and in his determination of lime as sulphate, in experiment No. 67, obtained 55·31 per cent CaO.

The results given above, it is seen, are as accurate as are usually obtained in parallel determinations as carbonate, and the ease and rapidity of manipulation are very much greater.

There is yet another class of operations, in which I thought the "ring-burner" might be of assistance, viz: the processes involving oxidation with fuming nitric acid, which at present are rather tedious. I have not as yet, however, given it a careful enough trial to enable me to decide positively, either for or against it.

Antimony.—The conversion of antimonous sulphide into antimoniate of the teroxide of antimony, by the aid of fuming nitric acid is, as every chemist knows, very tedious, often proving a failure, on account of the fusing together of the separated sulphur. I tried whether the operation could be shortened by the use of the ring-burner. Antimonous sulphide, dried on the filter, was taken, placed in a porcelain crucible, and after being moistened with a few drops of dilute acid, was covered well with fuming nitric acid. The heat of the ring-burner was then

applied, very gradually, to the upper rim of the crucible. Several times the oxidation was very successful, leaving only the white Sb_2O_3. On the other hand, in several tests, a globule of sulphur formed, which could not be gotten rid of, until the last heating. In no case, however, was there any loss from spurting. I then tried two analyses of tartar emetic, which I give here. In the first a globule of sulphur remained, and I had to drive it off at last by heat, giving of course considerable loss. In the other the sulphur was completely oxidized.

·3115 grms. tartar em. gave ·1294 grms. Sb_2O_3 =32·91 pr. ct. Sb.
·3206 " " " " ·1451 " " " =35·86 pr. ct. "

The formula $C_4O_6H_4K(SbO)+\frac{1}{2}H_2O$ gives 36·53 per cent Sb.

I have given these two tests for what they are worth. They do not allow me to recommend the use of the "ring-burner" here; but, if I can obtain better results on farther trial, the neatness and ease of the manipulation will recommend it.

Lead.—I also made some tests on the rapid conversion of plumbic sulphide into plumbic sulphate, but at present I have no quantitative results, and the qualitative results are not complete yet. I think, however, it promises well.

With regard to the "ring-burner" itself, I have little to say, as Dr. Gibbs speaks sufficiently explicitly about it. Of course it is best run with a water-blast or "water-tromp." I have, however, to run it with the bellows of the glass-blowing table, as I have no hydrant-water in my laboratory. This greatly increases the labor of the processes. With the constant blast it needs no attention whatever, after being regulated.

Gettysburg, Dec. 24th, 1873.

Art. XIX.—*On the Oxidation of Alcohol and Ether by Ozone;* by Prof. A. W. Wright.

It has been stated by Houzeau,* that alcohol exposed to the action of ozone is instantly oxidized, with the formation of aldehyde, acetic acid, and hydrogen peroxide, and that ether, under similar conditions, undergoes an analogous change, being even more rapidly oxidized, with the production of hydrogen peroxide. It does not appear, however, that either the conditions of the action of ozone on these substances, or the nature of the compounds formed, have been much further studied. With a view to determine some of these points, and especially to ascertain whether ozone could be advantageously used in the production of acetic acid from alcohol, an ex-

* Comptes Rendus, lxxv, p. 142, 1872.

tended series of experiments was made by the writer, the results of some of which are here given.

As ozone is easily resolved into ordinary oxygen by heat, it appeared probable that its action would be intensified by submitting the substances examined to its influence at a somewhat elevated temperature. In the first experiments accordingly, either the alcohol was itself heated, or its vapor was subjected to the action of heat in conjunction with the ozone. In later experiments alcohol at the ordinary temperature was used, both absolute, and mixed with varying quantities of water. The ozone was produced by passing dry oxygen through an ozonizing tube under the influence of electricity. In some of the experiments Houzeau's apparatus for this purpose was employed; in others that described by the writer in a former number of this Journal, used with statical electricity. All the connections of the parts of the apparatus traversed by ozone were made with glass tubes united with perforated corks which had been soaked in melted paraffine. The determinations of the amount of acid were made volumetrically, by means of a solution of caustic potash in distilled water, and the percentages given in the results express the proportion of acid obtained relatively to commercial acetic acid, with which the comparisons were made. As the latter contains about 25 per cent of anhydrous acid, a sufficiently near approximation to the absolute percentage of acetic acid would be obtained by dividing the results by four. In all cases the amounts obtained were very small. Commercial alcohol, which contained about 8·5 per cent of water, was used in the experiments numbered 1 to 5. The volume of liquid used in each case was 100 cubic centimeters.

1. In this experiment vapor of alcohol was passed into a flask kept at 100° C., by means of a water-bath, and ozonized oxygen driven slowly through the same flask. The mixture of gas and vapor was then conducted into another flask immersed in cold water, where the alcohol and products of oxidation were condensed. The operation was continued for one hour. The alcohol at the beginning was found neutral, but at the end of the experiment it gave a decided acid reaction. The percentage relatively to commercial acetic acid, that is, the strength of the dilute acid, as compared with the former, was 1·62 per cent.

2. Ozone and alcohol vapor were passed through a porcelain tube heated to a temperature of 200° or 250° C. Percentage obtained 0·81, of which but a portion was acetic acid, as the reaction was evidently different from that at a lower temperature, and other products were formed.

3. A small quantity of alcohol was placed in a large flask, and ozone passed into it at intervals, the flask being frequently

shaken vigorously. This was continued for ten or twelve hours. The percentage obtained was 3·17, or if reduced to the amount for one hour, about 0·32.

4. Ozone was passed through boiling alcohol, and the vapor condensed in a cool flask. Percentage 1·18.

5. Ozone was passed through boiling alcohol in a flask provided with a vertical condenser, by which the condensed liquid was returned to the flask, and thus repeatedly subjected to the action of the gas. Percentage 1·22.

6. In the following series of experiments alcohol was employed which had been mixed with quick-lime, and after standing several days was then distilled off. It contained less than two per cent of water. Four determinations were made, with alcohol alone, and with alcohol mixed with different proportions of distilled water. The liquid was maintained at the boiling point during the whole operation, a vertical condenser being used, as in the preceding experiment. The results are given in the following tables, in which the first and second columns give the relative amounts of the alcohol and distilled water in the mixtures, the third shows the actual percentage of acid obtained, the fourth the amounts corresponding to equal portions of alcohol, and the fifth those amounts divided by four, giving the approximate absolute percentage.

The numbers are reduced, to correspond to a continuance of each experiment one hour.

Alcohol.	Water.	Percentage in mixture.	Percentage in alcohol.	Percentage absolute.
100	0	0·55	0·55	0·14
50	50	1·66	3·32	0·83
10	9	0·93	9·30	2·32
5	95	1·66	33·20	8·30

7. The experiments in this series were made in the same way as the preceding, except that the alcohol was not heated, and the results are as follows:—

Alcohol.	Water.	Percentage in mixture.	Percentage in alcohol.	Percentage absolute.
100	0	0·59	0·59	0·15
50	50	0·34	0·68	0·17
10	90	0·08	0·80	0·20
5	95	0·09	1·80	0·45

In the determinations it was assumed that the acid obtained was acetic acid. This would be justifiable in all cases except those where the alcohol was highly heated, as, though a small quantity of formic acid is produced, shown by its action on nitrate of silver and otherwise, acetic acid constitutes the chief portion of the product. When a quantity of the liquid was neutralized with the potash solution, evaporated, and the residue treated with dilute sulphuric acid, a strong odor of acetic acid was given off. The products of the experiment in which the alcohol was highly heated were examined in the same way, but the odor was hardly to be recognized as that of acetic acid, having some resemblance to that of formic and butyric compounds.

Although the results are not perfectly concordant, as was to be expected, considering the varying conditions of some of the cases, and the feeble proportion of acid abtained, they agree in the main very well, and show clearly enough that the action of the ozone is influenced very materially by the presence of water, and by heat.

The table in No. 7 shows that as water is added to the alcohol, the total amount of acid produced decreases, but less rapidly than the alcohol, so that with each addition to the percentage of water a larger percentage of alcohol is acidified. Both this and the preceding table show that the increase is more rapid as the proportion of alcohol becomes small.

In No. 6, with the exception of the first case, in which the amount of acid is not greatly different from that of the first in No. 7, the numbers show a large increase in the total amount of acid, and a still greater increase relatively to the proportion of alcohol. This was due in part to the fact that, by the arrangement of the apparatus, the hot vapor was mingled with the ozone, and thus more thoroughly exposed to its action. A comparison of the results in Nos. 1 and 4, however, shows that it is to be attributed chiefly to the higher temperature. It will be seen also that the effect is more strongly marked, the greater the proportion of the water. In the fourth experiment of No. 6, about eight per cent of the alcohol was converted into acetic acid, being the highest proportion obtained.

It would be of interest to determine, if possible, the nature of the reaction by which the alcohol is acidified. As considerable quantities of aldehyde and hydrogen peroxide are always produced, it seems most probable that the action proceeds in the manner commonly assumed, namely, by the abstraction of two hydrogen atoms from the alcohol molecule, forming aldehyde, and hydrogen peroxide, together with water. The aldehyde would, in part, be immediately oxidized by the ozone, and in part by the gradual action of hydrogen peroxide. This

action would be greatly facilitated by heat, which decomposes both ozone and hydrogen peroxide. If the reaction is less simple, and the alcohol molecule is broken up, we might expect to obtain carbon di-oxide as one of the products. A special experiment with alcohol which was not heated, though continued for nearly two hours, showed that, if any, only a very small amount is eliminated.

It may be observed that the proportion of alcohol in the third and fourth cases of Nos. 6 and 7, is not very different from that in the wines and other liquors used in the manufacture of vinegar. Although the application of ozone for this purpose, by the methods followed in these experiments, would be neither practicable nor economical, it is not improbable that operations on a larger scale might give better results. Especially in the German or "quick" vinegar process, where a large surface is exposed, and a considerable rise of temperature is experienced, it is hardly doubtful that the process would be materially accelerated by passing ozonized air through the apparatus, and to accomplish this an ozonizer of moderate capacity would be sufficient.

Experiments similar to those above described were made with ether and ozone. The oxygen employed was dried by passing it through a wash-bottle containing strong sulphuric acid, and thence through a large U-tube filled with small fragments of pumice-stone freshly saturated with the concentrated acid. The oxygen, after passing from this through the ozonizer, was conveyed into a flask containing the ether, and bubbled from the extremity of a glass tube immersed in the liquid. Energetic action at once took place. Each bubble of the gas gave a little cloud as it broke at the surface, and the liquid in a few minutes lost its transparency and became opalescent. This effect was caused by the production of a liquid not miscible with the ether, and dispersed through it in very minute globules. After a time they gradually fell to the bottom of the flask, and coalesced, first into drops, and finally to a thin stratum of liquid.

After the operation had been continued for an hour or more, the heavy liquid was examined, portions of it being removed with a thin glass tube. It was found to be strongly acid, and when tested, by neutralizing it with potash solution, evaporating, and treating with dilute sulphuric acid, gave an unmistakable odor of acetic acid.

Tested with lime-water, and otherwise, the liquid gave evidence of the presence of a considerable proportion of oxalic acid, while its behavior with nitrate of silver and with ferric chloride indicated a small amount of formic acid.

A small quantity of manganese di-oxide was washed with distilled water and placed in a narrow test-tube. When a

little of the liquid was dropped upon this, copious bubbles of gas were given off, doubtless oxygen, though in too small quantity to be tested. With ether (containing no hydrogen peroxide) and chromic acid the liquid produced an intense blue color. It also immediately discharged the color of indigo-solution. These tests indicate the presence of a large percentage of hydrogen peroxide. Aldehyde also appeared to be indicated, though with less certainty than the other substances. The liquid then was apparently water, formed partly by the action of the ozone and partly by the condensation in the cold ether of traces of moisture left in the gas after passing the drying apparatus, and holding in solution the other products of the reaction, namely, hydrogen peroxide, acetic, oxalic, and formic acids, and probably aldehyde.

Yale College, Jan. 21, 1874.

ART. XX.—*Notes on some of the Fossils figured in the recently-issued Fifth volume of the Illinois State Geological Report;* by F. B. MEEK.

As stated by Prof. Worthen in a prefatory note to the paleontological part of the above mentioned volume, we had intended, not only to revise and extend the previously published descriptions of some of our own species, before sending the text of this volume to the press, but also to add full descriptions, with remarks on the affinities of all the forms illustrated on the accompanying plates, including many species that had been described by others from far inferior specimens to those contained in the splendid collections at our command.

Ill health, however, and other unavoidable circumstances, prevented the accomplishment of this design, and rendered it necessary merely to repeat the previously published descriptions of our own species, without modification, and to give ref erences only to the original descriptions of forms described by others, often from quite imperfect material. Fortunately the descriptions of our own species were originally pretty fully written out, as published in a series of papers in the Proceedings of the Academy of Natural Sciences at Philadelphia some years back, and generally require little modification. With the aid, however, of the unrivaled collections that we had for study, particularly those of the *Crinoidea*, mainly from Mr. Wachsmuth's collections, we could have added much information to all that was previously known in regard to the old species, the original descriptions of which are merely cited without note or comments in the text.

Although the figures we have given, and the rather full explanations accompanying each plate, will, it is hoped, enable the intelligent paleontologist to understand and appreciate the new information added to this department of science by these illustrations, some additional notes in regard to the many interesting types figured will doubtless be of service to students in using the volume. Of course, however, it will be readily understood that such notes prepared (here in Florida) without any of the type specimens, and but few of the numerous works of reference at hand, must necessarily be incomplete. I will, however, proceed to refer to such of the species figured as may seem to require some farther explanations, mentioning them in the order in which the figures occur on the plates, rather than with regard to natural arrangement, or to their relative positions in the text, as follows:

Actinocrinites sculptilis Hall; plate IV, fig. 2.—This form was originally figured and described by Prof. Hall, in the Iowa Report, from specimens showing only the body up to the base of the free rays. In a former volume of the Illinois Reports, we called attention to the very peculiar character of the free rays, and the equally unusual arrangement of the arms along the side of these rays, in this type; and the figure cited above was given to illustrate this character more fully. By reference to this figure, portions of two of these rays will be seen extending out, one on each side, and bearing pinnule-like appendages along their sides. These free rays, however, are not properly arms, as this term is usually applied in descriptions of the fossil Crinoidea, with open ambulacral furrows above, but rather, as it were, extensions of the body, as they are composed, on the dorsal or under side, of a direct continuation of each radial series of pieces: while on the upper or ventral side, they are each covered over by a series of fixed pieces, corresponding in all respects with those forming the vault of the body, from which they extend out continuously. This covering over of these free arm-like rays gives them the character of tubes, along each side of which there are small openings for the connection of the smaller lateral appendages seen in the figure.*

These smaller appendages, however, are not pinnulæ, as they would at a first glance seem to be, but really correspond in all respects to the true arms in all the other types of the *Actinocrinites* groups; and, as has been determined by the examination of other specimens, bear the true pinnulæ, or tentacles as they are sometimes called, along their inner margins.

Another species, as first shown by us in a former volume of the Illinois Reports, has the same peculiar arrangement of the arms along tubular free rays; but in this these free rays bifur-

* The structure of the bases of these arms is not well shown in the engraving.

cate once, the divisions being long, straight, apparently rigid, and support the true arms along each side. For the group including the species presenting these remarkable tubular extensions bearing the true arms, we have, in some of our papers, and in a former volume of the Illinois Reports, proposed the name *Steganocrinus.*

In this connection, it is worthy of note, that we now know species which, in the same way, agree precisely in all other respects with *Platycrinites*, that present exactly the same kind of radial extensions, having the true arms arranged in the same way along their sides. For this type I have proposed the name *Eucladocrinus*, in Dr. Hayden's Report of the U. S. Geological Survey of the Territories for 1871, page 378. Whether the groups of species presenting these peculiar characters should be viewed as subgenera under *Actinocrinites* and *Platycrinites*, or as separate and distinct genera, there may and doubtless will be differences of opinion, depending on the peculiar views of authors in regard to what should constitute generic, and what less important distinctions, among such animals.

Taxocrinus Thiemei Hall; plate IV, fig. 1.—Although this beautiful crinoid seems to differ in some of its minor details of structure from *Forbesiocrinus Thiemei* Hall, it is the form referred to that species by the collectors at Burlington, where the typical *F. Theimei* was well known.* It would not, however, properly fall into the group *Forbesiocrinus*, whether we regard that as constituting a distinct genus, or as only a subgenus under *Taxocrinus.* These two groups shade into each other by so many gradations, however, that it is not possible to divide the numerous species now known into two sharply defined *genera;* as was shown by us in the Proceedings of the Academy of Natural Science in 1865, page 183, where we referred the species *Thiemei* to the older genus *Taxocrinus.*

The great development and protuberance of the upper radial pieces in this crinoid, and the probably consequent drawing together of the parts above, give it a peculiar physiognomy, not seen in the typical *Taxocrinus* or *Forbesiocrinus.* Still it seems to show no differences of structure upon which it can be separated generically; while, in the small number of its anals and interradials (the only point of difference between *Taxocrinus* and *Forbesiocrinus*), it agrees *much* more nearly with *Taxocrinus*, as may be seen by comparing it with *Forbesiocrinus Wortheni*, plate XIV, fig. 2, and plate XV, fig. 7,† which is a typical *Forbe-*

* If I remember correctly, *F. Thiemei* was described as being without either anal or interradial pieces. Smaller specimens, however, believed to be the young of the form we have figured, have been found, that were nearly or quite destitute of interradial pieces, and seemed to agree exactly with the description of *F. Thiemei.*

† The specimen from which these two figures were drawn was found loose, and was evidently water-worn, so as to have lost its surface granules.

siocrinus, with the anal and interradial spaces filled by numerous pieces. The differences between both of these types and the allied group *Onychocrinus* will also be apparent by comparing them with *O. exculptus* L. & C., plate XIV, fig. 4.

Batocrinus pyriformis Shumard; pl. V, figs. 5*a*, *b*, *c*.—The original typical specimen of this species consisted of the body only, without the arms or ventral tube. Our figures, however, also illustrate, for the first time, the arms, a portion of the column and most of the ventral tube or proboscis. At the time our figures were drawn, and the explanations of the plate were prepared, the very fine specimen represented by figure 5*a* was fastened on a board, with the ventral tube made out by adjusting together several pieces, so as to include, with an intermediate piece, the terminal portion represented by fig. 5*c*. Misunderstanding Mr. Wachsmuth, to whom the specimen belonged, when he stated that the pieces of the tube, as adjusted together, were all known to belong to the same *species*, I left him with the impression that they were known all to belong to this individual *specimen*.

On subsequently inquiring more particularly about this, Mr. Wachsmuth, with his usual conscientiousness and candor, informed me that the upper pieces of the tube, as made out, although certainly known to belong to the same *species*, did not belong to this individual *specimen*. He assured me, however, that, on first seeing this specimen, as found embedded in the rock, the tube was as long as restored by him; but that, in detaching it from the matrix, this appendage broke, and some of the terminal pieces were lost among the loose rocks at the quarry, so that he afterward replaced the lost parts from another individual of this species.

On receiving Mr. Wachsmuth's letter containing this information, I struck out of the figure, on one of the proofs of the plate, the portion of the tube connecting figures 5*a* and 5*c*,* so as to leave the latter detached; but as I did not afterward see the explanations of the plate, the necessary correction there was unintentionally overlooked, and Mr. Wachsmuth thus wrongly made responsible for the assertion that the detached portions of the tube figured were known all to belong to the same individual specimen.

I mention the above facts, because, if the terminal part of the tube replaced from another specimen belonged to a *smaller individual*, it would necessarily make the extremity relatively too much attenuated, and the opening proportionally too small

Actinocrinites delicatus M. and W; plate VIII, fig. 2.—Since describing this little crinoid under the above name, Mr. Wachs-

* It may be proper to explain here, that, when plates or figures are mentioned in these notes, unless otherwise stated, they always refer to the Illinois Report under consideration.

muth has informed me that he has discovered at Burlington a series of specimens of intermediate sizes, that show it to be only the young or undeveloped condition of one of the large species of *Strotocrinus;* but, not having his letter at hand, I cannot say which. He states that, as it advanced in growth, the upper interradial, interaxillary and interbrachial pieces, with the overlying vault plates, were gradually developed, and, with the supraradial and brachial pieces, spread out so as to cause the remarkable dilation of the upper parts of the body and vault, so characteristic of the adult *Strotocrinus.* If so—and Mr. Wachsmuth's unequaled opportunities for observation, as well as his well known carefulness as an observer, render his opinion on such a point worthy of no little consideration—it would be a fact of much interest, since it would show that *Strotocrinus,* at one of the earlier stages of its growth, presents exactly the characters of *Actinocrinites.* This, however, would not necessarily prove the two types to be generically or subgenerically identical, since there are many examples, in various departments of natural history, in which two clearly distinct, but allied, genera agree in all essential generic characters, in their young state, until they advance to a certain stage of growth, which, in one, becomes its fixed adult condition; while the other goes on to develop the additional distinguishing characters. It would show, however, that *Strotocrinus* holds a higher position in the scale of development than *Actinocrinites.*

Looking at the figures only, without having the specimens at hand for farther study, it would seem to me quite as probable that our *Actinocrinites penicillus* (fig. 2* of the same plate cited above) may be a young *Strotocrinus.* We doubtless have much to learn yet in regard to the development of the fossil Crinoidea that will gradually come to light as more and more extensive collections accumulate; possibly to modify, to some extent, the prevalent views in regard to their classification.

(To be continued.)

ART. XXI.—*On the Connection between Isomorphism, Molecular Weight and Physiological Action;* by JAMES BLAKE, M.D.

HAVING been engaged for many years in investigating the action of substances when introduced directly into the veins or arteries of living animals, I have obtained some results which I consider are of interest under a purely chemical point of view. In the following table the substances experimented with have been arranged in groups according to their physiolog-

ical action, and after the name of each substance is the quantity required to be injected into the veins or arteries in order to arrest, in the course of a few minutes, the reactions between the different solids and fluids of the body which constitute life. These reactions are arrested in the same manner by all the substances contained in the same group; but in a distinct and totally different manner by substances contained in different groups. This is not the place to dwell on the physiological phenomena that have been observed. Details of many of my experiments will be found in the 3d, 4th, 5th and 7th volumes of the Journal of Anatomy and Physiology.

Note.—I have appended to each group a statement of the more marked physiological reactions that characterize the substances it contains.

GROUP 1.

Lithic sulphate,	2·56	Impede pulmonary circulation. Kill by their action on the lungs; do not affect the irritability of the heart.
Sodic nitrate,	1·30	
Rubidium chloride,	0·25	
Thallic sulphate,	0·20	Render the blood more fluid. Do not affect nervous system except Cs.
Cæsium chloride,	0·55	Do not impede systemic circulation except Ag.
Silver nitrate,	0·12	

GROUP 2.

Magnesic sulphate,	6·40	Do not affect the pulmonary or systemic circulation.
Ferrous sulphate,	2·24	
Manganous sulphate,	1·00	Exert a marked action on nervous system.
Nickel sulphate,	1·20	
Cobalt sulphate,	1·30	Arrest the action of the heart. Prevent the coagulation of the blood except Mg.
Copper sulphate,	1·20	
Zinc sulphate.	1·30	
Cadmium sulphate,	0·60	

GROUP 3.

Nitrate beryllium,	0·65	Impede the systemic and pulmonary circulation.
Sulphate alumina,	0·68	
Yttria nitrate,	0·25	Heart not affected.
Cerium chloride,	0·22	Blood coagulates firmly.
Ferric sulphate,	0·19	

GROUP 4.

Calcium chloride,	3·28	No effect on systemic or pulmonary circulation except Pb. Ventricles of heart paralyzed. Contraction of voluntary muscles after death.
Strontium nitrate,	2·64	
Barium chloride,	0·32	
Lead acetate,	0.76	

GROUP 5.

Palladium chloride,	0·064	Act on the heart.
Platinum chloride,	0·120	Render respiration intermitted. Impede systemic circulation. Change the physical properties of the blood.
Kalium chloride,	0·120	
Ammonium Iridium chloride,	0·064	

GROUP 6.

Ammonia nitrate,	3·00	Paralyze the heart. Impede systemic circulation. Favor the coagulation of the blood and cause convulsions.
Kalium nitrate,	0·33	

	GROUP 7.	
*Chlorhydric acid,	0·46	Impede systemic and pulmonary circulation. Increase the irritability of the heart (ventricles). Kill by arresting the respiration.
*Iodhydric acid,	0·62	
Bromic acid,	0·75	
Iodic acid,	1·00	
	GROUP 8.	
Phosphoric acid,	4·00	No well marked physiological effects in large quantities. Kill by arresting pulmonary circulation.
Arsenic acid,	4·00	
Antimony tartrate,	2·70	
	GROUP 9.	
Sulphuric acid,	1·7	Impede pulmonary circulation. Act on the nervous system.
Selenic acid,	1·4	

A simple inspection of the above table† will suffice to show the facts which have led me to submit these remarks to the Chemical Society, viz: the connection between isomorphism and physiological action of the compounds of the metals and metalloids, when they are introduced directly into the blood, and also amongst the more purely metallic elements, the general increase in the intensity of the physiological action of the bodies in each isomorphous group, as the atomic weight of the electro-positive element of the compound increases. The connection of physiological action with isomorphism, I published more than thirty years ago, in a paper read before the Royal Society in June, 1841, and subsequent investigations have confirmed the truth of the statement I then made. I was led to investigate the connection between the physiological activity of a substance and its atomic weight by a communication made by Dr. Rabuteau to the Academie des Sciences in 1869, in which it was stated that "the metals are more active physiologically according as their atomic weights are more elevated." A review of my experiments plainly showed that this was not the case; for instance, beryllium, with an atomic weight of 9 is far more poisonous than strontium with an atomic weight of 87; but the facts I had observed plainly show that in the case of the more purely metallic elements the physiological activity

* Injected into the arteries.

† The numbers contained in the above table can but be approximative, as must be the case in operating with a substance of such uncertain properties, as living matter subject to variations which in the present state of science we are unable to detect. The manner in which the experiments were performed was not calculated to furnish accurate data as to the smallest quantity of the different substances that would destroy life. After one or two preliminary experiments to ascertain the general physiological action of a substance, and the quantities in which it could be used, the experiments recorded were made by injecting the substance into the veins or arteries, in quantities sufficient to produce the physiological effects, but not so as to destroy life until three or four injections had been made. It is the sum of the quantities so used in all the experiments recorded that have furnished the numbers in the table, reduced, however, to the same weight of animal (for dogs 7 kilo., for rabbits 1·4 kilo.; rabbits were only used in the first group. As the experiments were all made in the same manner, the numbers thus obtained are fairly comparable.)

in the same isomorphous group generally increases with the atomic weight. For instance, in the first group, the relative physiological activity between the compounds of Li and K is 125 : 1 ; in the 2d group, between Mg and Cd 104 : 1 ; in the 3d group, between Be and Fe 3 : 1 ; in the 4th group, between Ca and Ba 10 : 1. In the 5th group, the quantities used were so small, and in the case of Pt and Ir double salts had to be used, so that the numbers representing the relative physiological activity hardly admit of comparison. In the whole group, there is great physiological activity combined with high atomic weight. In the metalloids this connection between physiological activity and atomic weight does not exist, although the particular reactions caused by each group is still dependent on their isomorphous relations, as closely as in the case of the true metals.

The only well marked exceptions that have been met with to the analogous action of isomorphous elements are in the salts of potash and ammonia. Both these substances differ entirely in their action from the other bodies in the soda group. I am aware that the isomorphism of soda and potash has been called in question by some chemists, and it certainly does not fit into the soda group, by the relative increase of its specific weight with its atomic weight. As regards the salts of ammonia, they are also totally distinct in their action from the salts of the soda group, resembling to a certain extent many of the organic poisons by their action on the nervous system. The salts of silver and of lead also differ in some respects in their physiological action from the other substances of the group to which they belong. They both give rise to the well marked reactions characterizing each group, yet they both produce certain effects on the capillary circulation in which they resemble each other, but in which they differ from other members of the group in which each is placed. Cæsium also differs from the other members of the first group by its action on the nervous system.* With these exceptions the substances contained in the same group agree with each other, in the effects they produce on the pulmonary and systemic circulation in their action on the heart, and on the nervous and muscular systems, and in the physical changes they give rise to in the blood. In the present imperfect state of our knowledge as regards the isomorphous relations of the elements, it would be useless to speculate on the nature of the changes induced on living matter by different groups of isomorphous substances.

These changes must be quite different from those occurring in ordinary chemical reactions, as in these reactions the greater

* It will be seen on referring to the table that these three substances present the most striking anomalies as to the connection of physiological intensity with increased atomic weight.

the atomic weight of a substance, the larger the quantity required to produce analogous chemical changes, whereas in these physiological reactions the reverse of this is the case. They would appear to be more closely connected with the phenomena of dissociation than with any other chemical process. Whatever the nature of these changes may be, they are evidently connected with the molecular constitution of the compound, as in the ferrous and ferric salt not only is the intensity of the physiological action increased by the change from a bivalent to a quadrivalent molecule, but the nature of the action is completely altered. The most important deductions from these experiments are—

1. In the changes induced in living matter by inorganic compounds, the character of the change depends more on the physical properties of the reagent than on its more purely chemical properties.

2. That the character of the changes is determined by the isomorphous relations of the electro-positive element of the reagent.*

3. That among the compounds of the more purely metallic elements, the quantity of substances in the same isomorphous group required to produce analogous changes in living matter, is less as the atomic weight of the electro-positive element increases.

4. That the action of inorganic compounds on living matter appears not to be connected with the changes they produce in the proximate elements of the solids and fluids, when no longer forming part of a living body, at least in so far as our present means of research enable us to judge.

5. That in living matter we possess a reagent capable of aiding us in our investigations on the molecular properties of substances.

San Francisco, California, Dec. 1st, 1873.

ART. XXII.—*On the Dissociation of certain Compounds at very low Temperatures;* by A. R. LEEDS, Prof. Chemistry, Stevens Institute of Technology.

IT has been shown by Fittig† that ammonic chloride, when in solution in water, is decomposed by boiling. H. C. Debbits‡ has recently investigated other salts of ammonia, especially the nitrate, sulphate, oxalate and acetate, and has found that all of

* In a memoir read before the Academie des Sciences, Paris, in June, 1839, I proved that on injecting saline solutions directly into the blood, this physiological action was determined by the electro-positive element of the compound being but little influenced by the acid with which it was combined.

† Ann. Chem. Pharm., cxxviii, s. 189. ‡ Ber. der Deutsch. Chem. Gesell., v, p. 820.

these liberate ammonia, not only when their solutions are boiled, but also, in case a current of pure hydrogen is passed through their saturated solutions, at the ordinary temperatures and even at 0° C. This latter observation is a confirmation of what was stated previously by M. Gernez,* that when an inert gas like hydrogen or nitrogen is passed through a salt in solution or in the fused condition, it causes the liberation of a certain constant quantity of that one of the constituents which is volatile at the temperature of the experiment. This is true of the hydrosulphates, the bisulphites, the biacetates and the bicarbonates, a solution of potassic bicarbonate "even at ten degrees liberating increasing quantities of carbonic acid." In like manner the nitrates may be made to set free a portion of the acid at temperatures far below those which are ordinarily regarded as their decomposing points.

The object of the present investigation is to establish :—

1st. That it is not necessary to change the atmosphere in contact with the particles of the salt held in solution, by passing a current of an inert gas, in order to induce dissociation at temperatures below the boiling point.

2d. That there is a certain fixed temperature, which is different in the various salts, at which the dissociated constituent can be detected and recognized by sufficiently delicate tests.

3d. That it is highly probable that the dissociation of these salts in solution is analogous to the evaporation of the solvent, and that while it arrives at a maximum, under ordinary atmospheric pressures, at the boiling points of their saturated solutions, yet it takes place in a diminishing proportion at much lower temperatures, in some cases even below their freezing points.

The reagent employed in these experiments was alizarin, an alcoholic solution of which will readily detect one part of soda in three million of water, and a correspondingly small amount of potash, ammonia, etc. The apparatus consisted of a small flask, closed by a cork through which a delicate thermometer was passed with its bulb immersed below the surface of the liquid. A short tube entering the neck of the flask at right angles, contained a coil of alizarin paper, dry and carefully supported out of contact with any moisture which might condense on the sides of the tube. The results of the experiments are given in the following table, Bar. 29·84—29·82 in.

The temperature of the solutions at the beginning of the experiments was 17°–20° C., and the increase was conducted very gradually and slowly, about a half hour being required for each determination. The alkaline reaction was made evident by a quick and sharp transition from yellow to red of the alizarin paper at the temperatures indicated. In the case of

* Comptes Rendus, lxiv, p. 606.

ammonic chloride it would at first appear that there was a progressively slow increase of the point of sensible dissociation with the dilution of the liquid, but this was probably owing to the extreme slowness with which the liberated ammonia from a very dilute solution diffused itself, rendering it difficult not to overstep the temperature actually requisite.

Liquid.	Reaction of Liquid.	Parts in 100.	Temp.	Mean.	Reaction of Vapor.
Ammonic Chloride,	Feebly acid.	10·60	37° C.	37°	Strongly alkaline.
" "	"	"	37°		" "
" "	"	5·30	38°	38°·5	Alkaline.
" "	"	"	39°		" "
" "		2·65	39°		" "
" "		"	40°	39°·3	Feebly alkaline.
" "		"	39°		" "
" "		1·325	39° 39°		" "
" "		"	39° 41°	39°·2	" "
" "		"	38° 39°		" "
Ammonic Sulphate,	Acid.	45·62	50°	50°·5	Alkaline.
" "	"	"	51°		"
" "	"	22·81	51°	51°·	"
" "	"	"	51°		"
" "		11·40	50°·5	50°·5	Faintly alkaline.
" "		"	50°·5		" "
Ammonic Oxalate.	Strongly alk.	Saturated.	−1°	−1°	Strongly alkaline.
" "		at 7°·5 C.	−1°		
Ammonic Acetate.	Acid.	Saturated.	55°	55°	Alkaline.
		at 17° C.	55°		"

The ammonic oxalate was surrounded by a freezing mixture, and when the mass was frozen, an alkaline reaction was obtained almost immediately on inserting the coil in the exit tube. The atmosphere surrounding the apparatus in this experiment was likewise below the freezing point. It is probable that the point of sensible dissociation was much lower than that observed.

Finally, this point of sensible dissociation depends on the circumstances of the experiment, and the delicacy of the apparatus and reagents employed in its detection. For when a thermometer and a coil of paper supported at the distance of 3^{mm} from the surface of the liquid were placed in a sealed flask containing the ammonic chloride solution employed in the first experiments, tabulated above, it was reddened at the expiration of an hour, the temperature being 20°, and when the flask was previously exhaused of air, at 17° C. The lower temperature in the last case was probably due to the rising of air bubbles into the vacuum above the liquid. The temperatures of sensible dissociation above given are not to be regarded therefore as absolute, but as relative and valuable only as indicative of the comparative dissociability of these salts when in aqueous solution.

Stevens Institute, Jan. 19th, 1874.

ART. XXIII.—*On the Influence of Color upon Reduction by Light;* by M. CAREY LEA, Philadelphia.

IN all metallic salts which suffer reduction by exposure to light, the facility of reduction varies with the acid to which the base is united. Thus in the case of iron, ferric oxalate and citrate are much more easily reduced than ferric sulphate. Further, the reducibility of any salt is generally much influenced by substances placed in contact with it. Thus silver chloride exposed to light alone, changes somewhat slowly to a violet color; in contact with silver nitrate it changes more rapidly and assumes a deeper color; and if, in addition, we place certain sorts of organic matter in contact with it, the change is still more rapid and an intense black color may result. Pure silver iodide, as I have shown elsewhere, undergoes no chemical decomposition when exposed, completely isolated, to the sun, but in contact with silver nitrate, and also with many other substances, it is extremely impressible. The sensitiveness to light of silver bromide also is greatly modified by substances placed in contact with it.

As respects silver bromide, a new and interesting view has been recently published by Dr. Herrman Vogel. He affirms that substances placed in contact with silver bromide do not merely affect its general sensitiveness to light, but also modify its impressibility by rays of different refrangibilities, so that spectra impressed on a silver bromide surface will not merely vary in general intensity, by changing the accelerating substance placed in contact with the bromide, but that the relative intensities of different portions of the spectrum will also change. That the change, moreover, will follow a certain law, to wit: that colored substances absorbing certain rays will increase the impressibility of the bromide to those rays which they absorb. Thus a colored substance (itself capable of uniting with bromine) which absorbs the yellow rays and radiates the rest of the spectrum, will increase the sensitiveness of silver bromide to the yellow ray. Dr. Vogel even affirms that he can render silver bromide as sensitive to the yellow ray as to the violet.

It seemed therefore a matter of interest to determine whether any general law existed that when a metallic compound capable of reduction by light was placed in contact with a body capable of being oxidized (or of uniting with Cl, Br or I, as the case may be), the capacity of reduction of the metallic compound by any particular portion of the spectrum would be influenced by the *color* of the body placed in contact with it. If,

for instance, a ferric salt be placed in contact with an oxidizable body of well marked color, will the reducibility of the ferric salt by particular rays be modified? And if so, will it follow the law announced by Dr. Vogel for silver bromide, that the sensibility of the reducible compound will be exalted to those rays which are absorbed by the body placed in contact with it?

To solve this question, I have made an extended series of experiments. But I have not been able to verify the existence of such a law. The results which I have obtained are briefly as follows.

Ferric Salts.

Ammonia ferric oxalate was selected as the most easily reducible of the ferric salts. To obtain accurate results with it, however, much care is needed in its preparation. It is necessary that it should be prepared entirely in the cold: if any heat is used to aid the solution of the ferric oxide in ammonia binoxalate, I find that there is danger of reduction and the product may contain ferrous salt, even a trace of which renders it unsuitable for use. Freshly precipitated, and still moist, ferric hydrate, if left in contact with a solution of ammonia binoxalate for about a week at ordinary temperatures, gives a pure product free from ferrous salt.

Strips of paper were first strongly colored with aurine, with aniline blue and aniline green; they were then impregnated with the ferric salt, and were exposed to light side by side with ordinary white paper similarly impregnated with the ferric salt.

The exposure of these and of all the following preparations was managed in the following manner. Colored glass was obtained of shades corresponding as nearly as possible with the colors of the spectrum. Violet and green glass could be found in commerce of suitable shades. The other colors were obtained by dissolving suitable transparent pigments in varnish and coating glass with it. With the aid of aniline colors and colorless varnish, the most brilliant shades were obtained, with a perfect transparency. These glasses were next cut into strips ten inches long and five-eighths wide and arranged to form a sort of artificial spectrum, under which papers of different preparation could be simultaneously exposed. It is evident that in some respects this mode of operating is less advantageous than that of exposure to a real spectrum. But this disadvantage is compensated by the possibility afforded of a most accurate comparison of the effects of the various substances, inasmuch as the different papers can all be exposed simultaneously and all receive precisely the same impression. There results an accuracy of comparison which can perhaps be obtained in no other way.

The papers prepared with ferric salt alone, and also those with ferric salt in contact with the colors named, were simultaneously exposed. They were then plunged into solution of ferridcyanide of potassium, which renders evident whatever reduction has taken place by the production of Turnbull's blue, the unreduced portions remaining white.

Result.—The series of experiments was carefully repeated three times. The aniline blue was found to be entirely without influence; the printed spectrum obtained corresponded in every respect with that of the plain ferric salt. The aniline green slightly diminished the impressibility, but not more in one part than another. Aurine produced this effect still more strongly.

Neither coloring matter exerted any specific influence on the impressibility by any particular portion of the spectrum.

Other coloring matters were tried without results of special interest, except that a cold aqueous extract of *safflower* (carthamus) much heightened the sensitiveness to the whole spectrum, perhaps doubling it. But its increase extended, as it was judged, equally to all the rays.

Potassium Bichromate.

In contact with *aurine*, potassium bichromate exhibited no change of action in its behavior to white blue or violet light, nor in the orange or red. But in the yellow it was distinctly less impressed than in the plain bichromate band.

The papers colored with aniline blue and green behaved like the plain bichromate, except that they were perhaps a little less sensitive to the whole spectrum. These results, including that with aurine, were obtained alike whether the exposure to light was short or long.

Potassium Ferridcyanide.

Papers colored with aurine, coralline, aniline red, blue and green, and with mauveine were exposed. The reduction was first brought out with ferric ammonia alum. The influence of that substance in darkening and setting the aniline colors was found very objectionable, and little could be learned from the bands so obtained. Ferric ammonia oxalate was then substituted with excellent results.

All of the six colors above mentioned acted by diminishing the impressibility of the ferrid-cyanide, so that the printed spectra obtained were all weaker than that of the plain ferridcyanide paper used for comparison. But the weakening was general throughout the range of the spectrum, and no relation could be traced as existing between the color used and the impression made by particular rays.

Rosaniline and aniline green weakened the sensitiveness very slightly, almost imperceptibly; mauveine and coralline much more, aurine and blue most of all.

The reduction undergone by potassium ferridcyanide may also be rendered evident by exposing the paper to the action of uranic nitrate, which strikes a deep red-brown with the ferrocyanide and a yellowish color with the unchanged ferridcyanide. A complete series of papers examined in this way showed that all the colors tried, rosaniline, mauveine, aniline green, aniline blue, coralline and aurine, diminished the facility of reduction at the less refrangible half of the spectrum, and most of all the blue and coralline. As respect the more refrangible half of the spectrum, all the colors acted injuriously, and each to about the same extent.

When ammonia ferric oxalate is mixed with potassium ferridcyanide in solution, and exposed to light, a violet color results which, by simply plunging into water, passes to a rich blue. As the action where these two substances are exposed together is somewhat different from that which takes place when one only is exposed and the other is applied subsequently, a series of papers was prepared with the two salts mixed, and combined with the colors already mentioned.

None of the six colors tried increased the impressibility of the sensitive papers to any ray of the spectrum, but the coralline, aurine and blue diminished the sensitiveness to the entire range of rays from red to violet. The green diminished the sensitiveness to the less refrangible end rather more than to the more refrangible end, and the rosaniline and mauveine produced scarcely any observable effect whatever.

A separate series of trials was made to test the effect of the colors on the impression of violet light as compared with white light, by giving much shorter exposures than in the preceding experiments. If coloring matters as such have any influence on the susceptibility to the action of particular rays, then a range of six colors extending from violet blue to deep red ought in some cases to favor the action of the violet, in others to interfere with it. But after very careful and repeated trials, it was found that all the colors lowered the sensitiveness to both violet and white, to both equally, and with all the colors to about the same extent.

Uranic Nitrate.

The same range of coloring matters were tried with uranic nitrate, the extent of reduction being made evident by the subsequent application of potassium ferridcyanide, which with uranous nitrate gives a burnt sienna colored precipitate.

The first series was tried with short exposures to violet and to white light only. In this case the mauveine appeared to give a slight increase of sensitiveness, but as this extended equally to white and to violet, no conclusion as to influence on specific rays could be drawn. The aniline green, blue and rosaniline diminished the general sensitiveness a little, the coralline a good deal, and the aurine nearly destroyed it.

Under the influence of the entire spectrum the following results were obtained.

Red and orange rays. Mauveine same as plain uranium salt; other colors less sensitive.

Yellow. Rosaniline same as plain uranium salt; other colors less sensitive.

Green and blue. All the colors less sensitive.

Violet. Mauveine same as plain uranium salt; all the rest less sensitive.

These effects are evidently not capable of being reduced to any general law.

Silver Chloride.

A number of experiments led to the following results:

Coralline increased the sensitiveness to all the rays, but especially to blue and violet, in which the increase is very considerable.

Rosaniline increased the sensitiveness to blue and violet, but diminished all the rest.

Aniline blue diminished sensitiveness to green, increased it to yellow, and was without effect on the rest.

Aurine diminished sensitiveness to all.

Mauveine and aniline green were without effect.

Litmus reddened by acetic acid strongly increased the sensitiveness to the blue and violet, and somewhat diminished it to the red and orange.

Here we have three red colors increasing the sensitiveness to the blue and violet. But one, coralline, increases the sensitiveness at the red end also, whereas red litmus and rosaniline diminish the sensitiveness at the red end.

Silver Iodide.

The character of the action of light to be investigated in the case of silver iodide and silver bromide differs essentially from that involved in the foregoing cases. In the cases examined up to this point, the reducing action was completed in the exposure, although this effect was in most instances only rendered evident by a double decomposition effected subsequently. But with silver iodide and bromide, light is only permitted to act for a brief space of time, and subsequently a strong image is built up upon this faint or invisible image by the precipita-

tion of silver through the agency of gallic acid or other reducing agent, thus producing a true "development." It is with these images developed by gallic acid that we shall have to do in this and the following section.

Silver iodide papers, imbued with various coloring matters and containing free silver nitrate, were exposed to the different rays with the following results:

Red and orange rays. None of the coloring matters tried increased the sensitiveness to these rays.

Yellow rays. Aniline blue and green increased the sensitiveness to these rays somewhat, mauveine perhaps a very little. Coralline diminished the sensitiveness a little, aurine and rosaniline a good deal.

Green rays The aniline green (a bluish green) increased the sensitiveness to the green ray somewhat, aniline blue (a violet blue) increased it a very little. Mauveine was without influence, whilst coralline, aurine and rosaniline gave weaker results than the plain iodide paper, the last two much weaker.

Blue rays. Aniline green is here again the strongest. Blue and mauveine increased the sensitiveness to the blue rays a little, coralline was without effect, aurine and rosaniline diminished the sensitiveness.

Violet rays. Aniline blue, green and mauveine all considerably increased the sensitiveness, coralline increased it a little, aurine and rosaniline diminished it a little. With ordinary white light the order of sensitiveness was the same as in the violet rays.

It does not appear that there exists any general law connecting the color of the substance placed in contact with the silver iodide, with increased or diminished sensitiveness to particular rays. A violet blue aniline color increased the sensitiveness to the yellow and green rays, but also had a similar effect upon the violet rays. Aniline green increased the sensitiveness to the violet, blue, green and yellow rays, but not to the orange and red; its tendency was to increase the sensitiveness of colors approximating to its own color, whereas coralline increased the sensitiveness to the rays which most differed from its own color.

Silver Bromide.

Silver bromide is at once the most important of all the sensitive substances known, and the most difficult as to the exact determination of its reactions, so much do these vary from very slight causes. Multiplied experiments were consequently made; thirty-five complete spectra were obtained, besides prints from detached portions of the spectrum. Below I give the substances in the order of the greatest sensibility which they conferred, beginning with those that gave the greatest.

Substances which conferred the greatest sensibility to the more refrangible half of the spectrum.	Substances which conferred the greatest sensibility to the less refrangible half of the spectrum.
Infusion of tea leaves,	Salicine,
Salicine,	———
Red litmus,	Plain bromide,
Coralline,	———
Aniline blue,	Aniline green,
———	Mauveine,
Plain bromide,	Aniline blue,
———	Aurine,
Anil. green,	Infusion of tea leaves,
Mauveine,	Coralline,
Aurine,	Infusion of capsicum,
Cold infusion of safflower,	Cold infusion of safflower (carthamus).
Infusion of capsicum.	

The substances above the "plain bromide" increased its sensitiveness, those below it diminished it, and in all cases to an extent corresponding with the order of rank in the respective columns.

In the above lists it will be noticed that there are not only colored, but also colorless and nearly colorless substances. After having made a number of experiments with silver bromide, I inclined to the opinion that the influence of the various matters placed in contact with it might have very little to do with their colors and might depend upon properties independent of color. To verify this, substances having either no color, or very little, but known to me from previous experiments to act powerfully on silver bromide, were experimented on. These were salicine, infusion of tea and infusion of capsicum; the first entirely colorless, the two last imparting to the sensitive paper only a faint neutral coloration. My expectation was verified; no substance tried exerted a more powerful discriminating action on the sensitiveness to individual rays than salicine, which substance rendered the silver bromide as sensitive to the red ray as to the green.

Generally speaking, the substances enumerated above exerted very much the same effect on the different colors at each end of the spectrum, that is, those that heightened or impaired the sensitiveness to the green acted similarly on the yellow, orange and red, and those that heightened or impaired the sensitiveness to the violet rays acted similarly to the blue rays and also to white light. The few interesting exceptions noticed were:

Red litmus (litmus reddened by the least possible quantity of acetic acid) and *coralline* produced an exceptional insensitiveness to the green rays.

Salicine conferred on silver bromide a remarkable sensitiveness to the red and orange rays, so that the whole of the less refrangible rays from green to red produced about an equal

impression. A repetition of the experiment with a shorter exposure gave the same curious result, the most curious of all the results attained.

Carthamus, *red litmus* and *capsicum* produced an exceptional insensitiveness to the red and orange rays.

No trouble was spared in these experiments to obtain accurate results. In each set to be compared with each other, each paper was floated or immersed, as the case might be, for an exactly equal time on or in solutions of exactly equal strength. As papers when hung up to dry are always more strongly imbued with the soluble matters at the lower end, care was taken in the successive treatments which each paper received to dry it with the same end uppermost, and in the exposure to light, to keep all the papers with their least sensitive ends to the same end of the spectrum: without this last precaution no concordant or reliable results could have been obtained.

The conclusions which I have reached seem to me to establish that there is no general law connecting the color of a substance with the greater or less sensitiveness which it brings to any silver haloid for any particular ray. At the same time, I do not consider that these results necessarily contradict or disprove the very different results obtained by Dr. Vogel. They, however, show that Dr. Vogel's results cannot be generalized. The explanation of the discordance may lie in the different conditions of the experiment. Dr. Vogel worked with silver bromide contained in a collodion film and combined with other substances not known (commercial bromide plates made by a secret formula). These substances may have themselves powerfully affected the properties of the silver bromide. Collodion certainly does; the reactions of silver bromide formed in the body of a pure paper differ from those which it exhibits when formed in a collodion film, probably because the collodior is made some time in advance and is always more or less decomposed by the alkaline bromides, which are dissolved in it. I am inclined to believe that the comparative indications which are obtained by the use of paper as a medium are more reliable than those obtained with collodion, because it is difficult if not impossible to make several collodion films in succession having equal thickness. And as the amount of impressibility to any given light or any given ray of light increases in proportion to the thickness of the film, it follows that in comparing two plates that have undergone different treatments, we are liable to ascribe to the treatment results that may depend only on the different thicknesses of the films. Whereas paper we can always obtain of uniform thickness, so that with equal immersion in solutions of equal strength, we are sure that the papers are equally charged with the substances to be tested.

ART XXIV.—*Note on Lignite Beds and their Under-clays;* by E. W. HILGARD, University of Michigan.

IN the January number of this Journal, Mr. Lesquereux defends his view of the origin of the lignite beds of the Rocky Mountain region, against supposed objections thus formulated by him:

1. That the lignite beds are of too small extent, or cover too limited areas, to have been formed otherwise than by the heaping of materials carried into small basins.

2. That the under-clays of the lignite beds contain no roots.

Having had extensive opportunities of observing lignite beds, from the Cretaceous to the Quaternary strata, in the States of Mississippi and Louisiana, I would add a few remarks to those of Mr. Lesquereux.

As regards the first point, I am altogether unable to see its force. Were the bays and marshes of the Louisiana coast region, or some portions of the Mississippi bottom, so depressed as to be covered over with deposit, and their peaty contents compressed into lignite, there would result just such a multitude of basin-shaped masses, from a few yards to many square miles in extent, and of variable thickness, as we now find in the Eocene lignitic formations on the Gulf border. The analogy goes even so far, that much of the lignite of those formations is obviously formed, not by any coöperation of the usual peat mosses, but altogether out of rushes and reeds, such as nowadays dispute the ground, in the coast marshes, with the Sabal, Cypress, Myrica, etc. In some cases, a semi-fluid peaty mass fills these smaller basins to a depth of 10 to 15 feet; in these, of course, as Mr. Lesquereux remarks, larger trees cannot grow. But the Cypress, Myrica, and even the *Magnolia glauca*, adapt themselves to this condition of things by sending out long tap-roots into the bottom clay, while their nutrition is performed by a crown of fibrous roots near the surface. Thus anchored, they may readily be swayed sideways in the soft mass, in every direction; but are difficult to pull up, although, under such circumstances, their size rarely exceeds a few feet.

These facts, as well as the well-known ability of the Cypress and Tupelo to exist and flourish in water maintaining some depth throughout the year, led me to consider the possible causes of the apparent absence of vestiges of roots from the under-clays of lignite beds, which early attracted my attention.

In the extensive marsh at the mouth of Pearl River, a solid clay, resembling very much the under-clays of lignite beds, or the bottom clays of Cypress swamps, is deposited for some distance on both sides of the river channel. The whole surface is covered by a dense growth of tall "round rush" (*Scirpus lacus-*

tris), whose roots form a dense, matted mass, over a foot in thickness, covering the clay soil, but penetrating it very little. Nevertheless, as the successive annual overflows raise the level of the clay deposit, the roots and root-stocks necessarily become imbedded in it, and one would expect to find their remains, or more or less distinct impressions, in the mass of the soil. Such, however, is the case only close to its surface, to the depth of a few inches at most. Lower down, we find only indistinct indications of the previous existence of vegetable forms, in a kind of cellular structure; and at the depth of a foot or more even this vanishes, and we have a solid blue or brownish clay, as free from organic remains or impressions as any under-clay of lignite beds, yet obviously of the same origin as the soil proper, above.

The same thing, precisely, may be observed in sections of Cypress swamps, both ancient and modern, on the Mississippi, Arkansas and Red River. Even where the Cypress stumps are perfectly preserved, their roots are often seen to terminate at a short distance, in rather an abrupt point of heart-wood; and beyond, their course is scarcely, or not at all, traceable in the solid clay.

The cause of this complete obliteration of spongy roots or spongy parts of roots is doubtless to be sought in the oxidizing influence of ferruginous solutions percolating from above, and the subsequent action of pressure upon the yielding mass.

In the more or less definitely porous under-clays of the coast marshes, the cavities are almost throughout lined with a green or yellowish-green, semi-gelatinous film of what, on exposure to air, becomes a plainly visible coat of iron rust. In the Cypress swamp under-clays such a film may often be seen to form the inside lining of a cavity still possessing the shape of a root, with, perhaps, a free central core of lignitic matter still existing, out of contact with the walls. And the original course of roots may often, but not always, be traced by that of a thin, vein-like ferruginous film, completely flattened out, so as to escape ordinary observation. If, by a subsequent process of reduction and solution, this film were also to be removed, not a trace of the original root would remain.

Again, the peculiarly "massy" cleavage of these under-clays is not only very often marked by minute films of (sometimes almost red) hydroferric oxide, but, on close examination, they frequently exhibit a multitude of minute "slickensides," proving the occurrence in the mass of internal movements, doubtless resulting from compression. That similar clays exhibit, at Petite Anse and other points, a glacier-like motion down hill, I have elsewhere* stated.

It appears to me that in these two agencies combined we

* Smithsonian Contr. Knowl., No. 248, p. 18.

have an adequate explanation of the apparent absence of organic remains from many under-clays, not only of lignites, but also of Paleozoic coal beds. That the leaching process which deprived the coal beds of all the ash ingredients necessary to vegetation, has also been instrumental in the removal of iron and organic matter from the Carboniferous fire-clays, has been often suggested; but the efficacy of the process, when combined with pressure, to obliterate all traces of the softer parts of plants and animals, imbedded in clays, has hardly been sufficiently dwelt upon. That another phase of the same agencies has been instrumental in obliterating the teeming fauna of the Port Hudson beds, whose character can now be studied only in a few limited localities, I have already shown.* And there can be little doubt that the absolute dearth of organic remains which has thus far frustrated all my attempts to gain a definite clue to the age of the "Grand Gulf" beds of the Gulf border, is largely due to the same cause, and not to the conversion of the Mexican Gulf into a "Dead Sea" during the Post-Eocene Tertiary period.

Lignite beds composed of drifted materials are not rare in the Gulf border, from the lowest Cretaceous beds to those of the Champlain era. But they are usually very much localized, and consist mainly of driftwood, which is not only over- and underlaid by sandy materials, but also intermixed with them. Beds of compact lignite underlaid to any great extent by sand, are quite exceptional.

ART. XXV.—*On recent Deep-Sea Dredging operations in the Gulf of St. Lawrence;* by J. F. WHITEAVES.

DURING the summer of 1873, the Hon. the Minister of Marine and Fisheries of the Dominion of Canada very kindly placed one of the government schooners at my disposal, for dredging purposes. These investigations, which were undertaken on behalf of the Natural History Society of Montreal, had, as their primary object, an examination into the present condition of the Marine Fisheries of the Gulf, and were supplementary to similar explorations carried out by myself in the summers of 1871 and 1872. In the present paper, a short descriptive account will be attempted of some of the most interesting zoölogical specimens collected in 1873. Nearly nine weeks were spent at sea (from July 18th to September 8th); and during this time, although the weather was often unfavorable, we nevertheless got about seventy successful hauls of the dredge. The cruises were essentially four in number, but on the whole the first yielded the greatest number of novelties.

* Smithsonian Contr. Knowl., No. 248, p. 12.

Cruise 1.—The first two weeks were devoted to an examination of the deep water in the center of the mouth of the river, between Anticosti and the Gaspé Peninsula. The most interesting specimens were obtained in from 200 to 220 fathoms, mud; and among them are the following:

FORAMINIFERA.—*Marginulina spinosa* M. Sars; a large *Triloculina* allied to *T. tricarinata*, perhaps *T. cryptella* D'Orb.; curious arenaceous forms, new to me, some of which are simple and unbranched, others widely triradiate, and a third series are irregularly cruciform, and even five and six-rayed. They are all, most likely, forms of one species; but whether they are the *Asterorhiza limicola* of Sandahl or not, I have at present no means of ascertaining.

SPONGES.—One specimen of *Trichostemma hemisphæricum* M. Sars; one of *Cladorhiza abyssicola* M. Sars; and about a dozen of the *Hyalonema longissimum*, of the same author, were taken in 220 fathoms. With these occurred another species, which is either a true *Tethea*, or belongs to a closely allied genus. In shape it is more or less pyriform, somewhat triangular in section, and with a flattened base. There are three orifices, corresponding to the three angles, of which two are basal. These are connected on two sides by a perforated canal or tube. The front basal orifice is partly closed by an outer fine open network and an inner and coarser one of siliceous spicules, the latter not very unlike those at the apex of *Euplectella;* and this opening seems to be the point of attachment to small stones, etc. The whole sponge is densely hispid with projecting spicules, which are sometimes of considerable length. These are mostly very attenuate; some of them are simple, and these are either straight or flexuous; others are simply ternate or biternate at one end; some again are anchorate at the extremity, with three or four slender flukes. In its canal connecting the three external and larger openings, and in its beautiful open network of spicules, it seems to differ generically from *Tethea*. In the shape of its spicules, but not in some other respects, it resembles the *Dorvillia agariciformis* of Mr. W. S. Kent, and the *Tethea muricata* of Bowerbank. As the Canadian sponge may possibly be the same as Dr. Bowerbank's imperfectly characterized species, I refrain for the present from giving it a name. It is only fair to add that before I had dredged this species in a living state, my friend Mr. G. T. Kennedy, M.A., had found specimens in the Post-Pliocene clays of Montreal, which are undoubtedly conspecific with it.

ECHINODERMATA.—*Schizaster fragilis* Dub. & Koren, and *Ctenodiscus crispatus*, are common in the deep-sea mud, as are also *Ophiacantha spinulosa* M. & T., and an *Amphiura* whose specific relations are still obscure. The Ophiuridæ collected

during this cruise have yet to be studied. One living example of **Ophioscolex glacialis* M. and T. was dredged in 210 fathoms, to the southwest by south of the Southwest Point of Anticosti.

NOTE.—I am indebted to Prof. Verrill for the identification of several critical species, to whose names an asterisk (*) is prefixed; and the difficult Crustacea, whose appellations are preceded by a dagger (†), were kindly determined for me by Mr. S. I. Smith.

ACTINOZOA.—A few individuals of *Pennatula aculeata* Dan., var., and of *Virgularia Ljungmanii* Köll., were taken in the deep-sea mud, together with large tubes apparently belonging to *Cerianthus borealis* Verrill, though the animal of this latter species has not yet been taken in the Gulf. *Cornulariella modesta* Verrill was collected (in 1871) at depths of 220 fathoms, between the east end of Anticosti and the Bird Rocks.

POLYZOA.—A beautifully perfect specimen of *Flustra abyssicola* of G. O. Sars, showing the singular avicularia, so characteristic of the species, was dredged in the center of the mouth of the river, at a depth of 220 fathoms. Two examples of *Hornera lichenoides* (Linn.) and one of a peculiar variety of *Bugula plumosa?* were dredged in the same place. *Escharella palmata* (M. Sars) was also sparingly taken in deep water.

MOLLUSCA.—The most abundant species collected at greater depths than 150 fathoms are *Pecten Grœnlandicus* Ch., and *Arca pectunculoides;* but *Portlandia lucida, P. frigida, Philine quadrata, Cylichna umbilicata* Mont., *Dentalium attenuatum*?* Say, and *Siphonodentalium vitreum* Sars also occurred, though more sparingly. Two living specimens of *Cerithiopsis costulata* Möll. (the *Bittium arcticum* of Mörch) were dredged in the 220 fathom locality.

CRUSTACEA.—The deep-sea Crustacea are of unusual interest. Among them is a living specimen of *Calocaris MacAndreæ* Bell, the first, I believe, that has been observed on the American side of the Atlantic. In the same region, four specimens of a crustacean were collected, which belong, in my judgment, to a new genus.† In its characters, this genus (for which I venture

* If the shell described by the late Dr. Gould as *Dentalium dentale* be really the *Dentalium attenuatum* of Say, the latter name is much prior to Stimpson's *D. occidentale.* Having received a number of Norwegian specimens of *D. abyssorum* Sars, through the kindness of Mr. Jeffreys, and compared them with the St. Lawrence longitudinally ribbed species, I cannot see any differences which in my judgment are sufficient to separate them. At the same time, *Dentalium striolatum* St. seems to me a perfectly distinct and good species.

† *Munidopsis curvirostra,* nov. gen. et sp. External antennæ about equal in length to the carapace and its rostrum; internal ones very short, not reaching farther than about one-fourth the length of the beak. Eyes *rudimentary,* longitudinally oval, light yellowish in color; *cornea devoid of facets.* Carapace squarish, but longer than broad, with an outwardly directed straight spine on each of the front angles. Upper surface of the carapace granulate, hispid, transversely irregularly plicate. In the center there are two dorsal spines, placed one above the other, but at some distance apart. These, as are two similar spines on the tail segments, are all

to propose the name *Munidopsis*) approaches nearer to *Munida* than to *Galathea*. On some future occasion I hope to be able to give a detailed description, with figures, of this form; for the present a short diagnosis only of some of its salient points will be attempted. Of the limited genus *Munida*, only two or three species are known at present. *Munida rugosa* (Fab.) is the same as *Munida Rondeletii* of Bell, and *Astacus Bamffius* of Pennant. The other species are *M. tenuimana* of G. O. Sars, and *M. Darwinii* of Bell.

The following additional species of Crustacea were collected from the deep-sea mud: †*Hippolyte Fabricii* Kroyer; †*Diastylis*, sp.; †*Pseudomma roseum* G. O. Sars; †*Thysanopoda neglecta?* Kroyer, and another large species; *Stegocephalus ampulla* Phipps; †*Harpina*, sp.; †*Epimeria cornigera* Fab.; †*Halirages fulvocinctus* Bœck; †*Melphidippa*, sp.; *Phoxus Kroyeri* St.; *Munnopsis typica* M. Sars; *Anthura brachiata* St.; and †*Nebalia bipes* O. Fab.

Fishes.—A fine living example of *Macrurus rupestris* (Fab.), the *M. Fabricii* of Sundevall, was brought up by "tangles" from a depth of about 200 fathoms.

During this cruise we were driven into Gaspé Bay for shelter from a heavy gale, blowing outside, and were detained there about four days. At the entrance of the bay, some dredging was done in depths of from 30 to 50 fathoms. The most interesting species obtained here were *Myriotrochus Rinckii* Steenstr.; *Priapulus caudatus;* both species of *Hyas;* a species of †*Eudorella;* *Acanthozone*, nov. sp., fide S. I. Smith; †*Syrrhoë crenulatus* Goes (several); †*Vertumnus serratus* Goes; †*Pontoporeia femorata* Kroyer; †*Haploops*, sp.; †*Melita dentata* Kroyer, and an allied species; as well as some interesting sponges. †*Gammarus ornatus* Edwards was abundant at low-water in St. George's Cove; it appears to be an abundant littoral form throughout the gulf.

Cruise 2.—We left Gaspé Basin on August 2d, intending first to examine the two largest of the inshore banks, the Orphan and the Bradelle. At the outset the weather was very stormy, so we got under the lee of Bonaventure Island, and dredged out-

exactly in a line with the rostrum, and the whole four point forward. Rostrum *simple* (without the spine on each side of the base so characteristic of *Munida*), *conspicuously curved upward*, stout at the base and gradually tapering to a fine point. A single spine in the center of the first and second tail segments, the rest devoid of any. Anterior pair of legs about as long, but not longer, than from the apex of the rostrum to the end of the tail, extending a little beyond the tips of the outer antennæ. The following are the measurements of an average and apparently adult female: length, from apex of rostrum to tip of tail, 1·38 inch; of carapace, including the rostrum, ·69 inch; of exterior antennæ, ·75 inch; of anterior legs, ·94. Inhabits the center of the mouth of the St. Lawrence River, between Anticosti and the south shore, in from 180 to 220 fathoms, and probably burrows in the deep-sea mud. From *Munida* it may at once be distinguished by its curved and simple rostrum. In the rudimentary character of its eyes it closely resembles *Calocaris*, but not in many other respects.

side the northern entrance to the Bay des Chaleurs, from Cape Despair to a little below Grand Pabou. *Ophioglypha Sarsii*, of large size, was abundant here, and two specimens of *Myriotrochus Rinckii* were taken in the same place. The crustaceans from this region are unusually interesting: among them are †*Hippolyte macilenta* Kr.; *Thysanopoda neglecta?* Kr.; †*Pseudomma* (nov. sp.); species of †*Mysidæ* "near to *Erythrops* and *Parerythrops* of G. O. Sars"; †*Eudorella*, sp.; †*Leucon nasicus* Kroyer; †*Acanthostephia Malmgreni* Bœck; *Œdiceros lynceus* M. Sars; †*Aceros phyllonyx* Bœck; †*Byblis Gaimardii* Kroyer; †*Pontoporeia femorata* Kroyer; a species of †*Melita*. Also a curious fish, at present undetermined.

The breeze moderating, we at once made for the Orphan Bank, and devoted three days to dredging on it, remaining on the ground during the night so as to lose no time. The Orphan Bank, which is situated nearly opposite the entrance to the Bay des Chaleurs, is a stony patch, as are most of the fishing banks, many of which are not mapped out in the charts.

The masses of rock are often of large size, and consist chiefly of a reddish sandstone (perforated by *Saxicava* and *Zirphæa crispata*) associated with a few scattered pieces of Laurentian gneiss, &c. Soft-bodied organisms are peculiarly plentiful on this bank. The most characteristic of these are *Alcyonium rubiforme* Ehr., small varieties of *Metridium marginatum*; *Ascidiopsis complanatus*, of unusual size and abundance; various other Tunicates; and quantities of common Ophiurids and Asterids. †*Metopa glacialis* Bœck was occasionally met with between the inner and outer tunic of *Ascidiopsis*. The stones are often covered with encrusting sponges, of two or three species, together with a slender, cylindrical, and rarely branched, form; *Grantia ciliata* was frequent, and with it there occurred another calcareous sponge which Prof. Verrill has identified as the *Ascortis fragilis* of Hæckel. Hydrozoa and Polyzoa are exceedingly abundant on this bank; the former seem to be mostly common northern forms. Among the latter, *Myriozoum subgracile* D'Orb.; *Celleporaria incrassata* Lam.; *Cellepora scabra* Fab.; *Eschara cervicornis?* Pallas; *Caberea Ellisii*; and other species, were fine and frequent. Two fine specimens of *Porella lævis* (Fleming) were dredged at this locality. **Boltenia ciliata* Möller; **Molgula pannosa* V.; *Cynthia pyriformis* (Rathke); and *C. monoceros* Möll., occurred sparingly among the other Tunicates.

Among the Echinoderms are *Pteraster militaris*, *Asterias Grœnlandicus*, and *Psolus phantapus*. The rarest of the Orphan Bank Mollusca are *Amicula Emersonii* (Couth.), fine and frequent; *Mamma immaculata* (Totten); *Trophon craticulatus* (O. Fab.); *Buccinum tenue* Gray; *Neptunea Spitzbergensis* (Reeve); *Tritonofusus Kroyeri* Möll.; *Astyris Holbollii* Beck; and a few

Astarte lactea of Brod. and Sowerby. Crustacea are peculiarly plentiful on this bank, particularly the two species of *Hyas; Eupagurus; Pandalus annulicornis; Crangon boreas; Nectocrangon lar* (fine); *Hippolyte spina;* †*H. Phippsii;* and †*H. pusiola.*

The Amphipods are represented by *Acanthozone cuspidata* (Lep.); *Tritropis aculeatus* (Lep.); and *Eusirus cuspidatus.* The Isopods by *Idotea marmorata* Packard, and by a *Bopyrus* which was found burrowing under the carapace of the common *Pandalus.* A small species of *Nymphon* was also dredged here.

At the end of the third day a stiff breeze from the southwest sprung up, accompanied with rain, and in consequence of this we made for Miscou Island for shelter. As soon as the gale moderated we proceeded to the Bradelle Bank, and on our way made one cast of the dredge between it and Miscou. In this haul, specimens of †*Hippolyte macilenta;* †*Pseudomma*, nov. sp.; †*Byblis Gaimardii;* †*Ampelisca*, sp.; †*Ptilocheirus pinguis* St.; †*Melita dentata;* and †*Pontoporeia femorata*, as well as many Annelids, were collected.

The Bradelle Bank, which is situated almost due south of the one previously described, is also a stony patch, but the pieces of rock are usually small, and there is an admixture of gravel, coarse sand and mud. Its fauna is characterized by the abundance of its Mollusca, and by the apparent absence on it of many of the softer organisms so abundant on the Orphan Bank. The Hydrozoa and Polyzoa of the two banks are very similar, but on the Bradelle fine specimens of *Tubulipora lobulata* Hassall, were collected. The most abundant shells on the Bradelle are *Astarte lactea* Brod. and Sow., *A. elliptica*, and *A. Banksii; Venus fluctuosa* Gould; *Cardium Grœnlandicum; Crenella nigra; C. lævigata; C. glandula; Macoma calcarea; Panopœa Norvegica;* and *Cyrtodaria siliqua.* Its greatest rarities are a single living example each of *Tritonofusus latericeus* Möller, and *Volutopsis Norvegicus* Chemn. *Rhynchonella psittacea*, of large size, is common on both banks. *Astrophyton Agassizii; Ophioglypha Sarsii*, large; *O. nodosa;* and *Psolus phantapus* are frequent on the Bradelle, where also a fine living specimen of *Ophiocoma nigra* Müller was obtained. The Crustacea of both banks are for the most part similar, but on the Bradelle a few additional species occurred. These are *Crangon vulgaris;* †*Diastylis*, sp.; †*Ampelisca*, two species; †*Haploops*, sp.; †*Byblis Gaimardii;* †*Ptilocheirus pinguis;* †*Harpina*, sp.; †*Paramphithoë pulchella* Bruz.; †*Œdiceros lynceus;* †*Vertumnus serratus;* and †*Nebalia bipes.*

These two banks seem to be outliers, so to speak, inhabited by a purely arctic fauna, and surrounded almost entirely by a more southern assemblage. The shores of the Magdalen Group, of Prince Edward and Cape Breton Islands, as well as the whole of Northumberland Straits as far north as the southern entrance

to the Bay des Chaleurs, are tenanted by a somewhat meager Acadian fauna. Owing to the shallowness of the water on these two banks, the temperature is probably higher by some four or five degrees than the average of that in the northern part of the gulf. In sailing from Point Miscou to the Bradelle Bank we found the temperature of the bottom (Miscou Point, bearing northwest half north, 22 miles distant) was 42° Fahr. After examining the Bradelle Banks, we made for Pictou, Nova Scotia, and arrived there on the afternoon of August 11th.

Cruise 3.—Leaving Pictou on the 13th of August, we dredged to the S.W. and S.S.W. of Pictou Island, then to the N.E. and N.N.E. of Cape George (N. S.), and from there to a little distance off Port Hood, C. B. We next stood over to the east point of Prince Edward Island, dredging at intervals on the way. After this we examined the Milne Bank, also various parts of the bottom from there to Cape Bear (Prince Edward I.), and to the north of Pictou Island, and got back to Pictou on the 16th of August.

From Pictou to Port Hood and along the west side of Cape Breton, the sea bottom consists of red clayey mud, in which annelids are remarkably numerous and often of large size. At almost every cast of the dredge, tangled masses of tubicolous annelids (inhabiting tubes of from the $\frac{1}{16}$th to a quarter of an inch or more in diameter, and from one or one and a half inches to nearly eight inches in length came up in handfulls. These, together with large naked species, are so abundant as to form more than two-thirds of the whole number of specimens taken. One specimen of †*Diastylis quadrispinosus* G. O. Sars, was dredged off Pictou Island. Hydrozoa and Polyzoa are tolerably abundant, and sometimes very fine, in the red mud; these have not yet been examined, but among them are *Sertularia argentea* of unusually large size, and a bushy species of *Gemellaria*. *Alcyonium carneum* Ag., is one of the characteristic species of the eastern part of this area, as is also an apparently undescribed species of *Priapulus*, very distinct from *P. caudatus*. Tunicates are not unfrequent in the red mud; the commonest of which are *Pelonaia arenifera* and *Eugyra pilularis*, while **Glandula fibrosa* St., occurred more rarely. With these, about sixteen species of shells were collected; they are all characteristic Acadian species. The temperature of the mud seems to range from 40° to 42° Fahr. Off Port Hood, two large specimens of a Holothurian were taken, which exactly agree with the drawing and description of the *Cucumaria pentactes* of O. F. Müller, as given by E. Forbes in his British Starfishes.

Off the east point of Prince Edward Island the bottom is sandy, and as the depth where we dredged does not exceed

fifteen or twenty fathoms, the summer temperature is high, being affected by surface conditions. Three small specimens of *Echinocucumis typica* M. Sars were collected here, as well as examples of **Molgula papillosa* V. and *M. producta* St. On the Milne Bank we dredged quantities of the common *Echinarachnius;* an abundance of fine Hydroids and Polyzoa; a few shells; and some small algæ.

Between Cape Bear and Pictou Island the bottom is sandy, with shells and a few small stones. Three kinds of sponges were collected here, many hydroids, echinoderms (all common forms), annelids, crustacea, and tunicates. Among the latter are specimens of **Molgula littoralis* V. Shells were particularly abundant, among them are *Pecten tenuicostatus*, *Modiola modiolus*, *Crenella nigra*, *Astarte undata* Gould, *Cyprina Islandica*, *Callista convexa*, *Pandora trilineata?*, *Crepidula fornicata*, *Lunatia triseriata*, *Mamma immaculata*, and several species of *Bela*.

The fauna of the region north of Pictou, between the west coast of Cape Breton and the east of Prince Edward Island, is essentially of an Acadian type. To the north, northwest, and west of Cape Breton, the deep water assemblage has probably an Arctic character.

In the marine slip at Pictou, I collected specimens of *Teredo navalis* and *T. Norvegica*, burrowing into the black birch of which the roller frames of the cradle are composed. At Souris, (Prince Edward I.), the common periwinkle of England (*Littorina littorea*) was plentiful, and it was subsequently observed at Charlottetown. An *Argulus*, closely allied to *A. Alosæ* of Gould, if not identical with it, was taken off Pictou Island, in towing nets, attached to *Gasterosteus biaculeatus?* and other small fishes. *Idotea irrorata* Say, was common on the surface at the same place, and was subsequently obtained at Shediac Bay, and elsewhere. On the shores of the Magdalen Islands it is tolerably common.

Cruise 4.—In the last cruise we endeavored to explore both sides of Northumberland Straits, and dredged from Pictou as far to the northwest as Miramichi Bay. Leaving Pictou on the 19th of August, we first dredged a little to the N.N.W. of Pictou Island, and were then compelled by stormy weather to take shelter in Shediac Bay. Being detained at Point du Chene for two days, we availed ourselves of the opportunity to examine the oyster beds of Shediac Bay. On these beds, from low water mark down to three fathoms, the following species were met with:

Crustacea.	Mollusca.
Cancer irroratus *Say.*	Ostrea borealis *Lam.*
Crangon vulgaris *Fab.*	O. Virginiana *Lister.*
†Gammarus ornatus *Edw.*	Mytilus edulis *Linn.*
Idotea irrorata *Say.*	Modiola modiolus *Linn.*

Mercenaria violacea *Schum.*
Gemma Tottenii *St.*
Callista convexa *Say.*
Petricola pholadiformis *Lam.* and var. dactylus.
Mactra solidissima *Chemn.*
Mya arenaria.
" truncata.
Angulus tener *Say.*
Thracia Conradi (fine and frequent).
Pandora trilineata? *Say.*
Solen ensis, v. Americana.
Teredo, sp. (in a spruce log).
Haminæa solitaria *Say.*
Cylichna pertenuis *Migh.*
Lottia alveus *Conrad.*
Crepidula fornicata *Linn.*
" unguiformis *Lam.*
Paludinella minuta.
Odostomia trifida *Totten.*
Turbonilla interrupta *Totten.*
Lunatia heros *Say.*
Bittium nigrum *Totten.*
Nassa obsoleta *Say.*
" trivittata *Say.*
Astyris lunata *Say.*

ECHINODERMATA.

Asterias vulgaris *St.*
Cribella sanguinolenta.
Echinarachnius parma.
Echinus Drobachiensis.
Caudina arenata (*Gould*).

Leaving Shediac by daybreak on the 22d of August, we dredged from that place to the Egmont Bank, and stood back again to the south shore the same evening. The Egmont Bank is a small rocky patch, situated between Shediac Bay and Cape Egmont, Prince Edward Island. The depth on it is less than ten fathoms, and the bottom consists of coarse sand and stones, the latter covered with *Laminariæ* and smaller algæ, and perforated by *Petricola pholadiformis*. Annelids are numerous in the sand, from which also about twelve species of shells were collected. Early the next morning (August 23d), we stood over to the Prince Edward Island side, and dredged along the outside of Bedeque Bay, from off St. Jacques to a little to the south of Sea Cow Head. In the afternoon a falling barometer indicating the imminent approach of a storm, we made for Charlottetown, and reached there only just in time to weather out the memorable gale of the 24th of August. We subsequently managed to dredge in Hillsborough Bay, also, on the opposite shore, off Pugwash Harbor, N. S., and off Shediac, Buctouche and Richibucto, in New Brunswick, and on the 9th of September I left the schooner and proceeded home. On the Prince Edward Island side of Northumberland Straits proper, the bottom is usually a red (Triassic) clayey mud, while on the New Brunswick side it is generally sandy. The fauna of the Straits is of a meager Acadian type. A few sponges, hydriods and crustaceans collected here have yet to be studied. The annelids are fine and frequent, but the echinoderms are all very common species. At depths of more than four fathoms, in Northumberland Straits, the following species were collected:

CRUSTACEA.

Homarus Americanus (fry.)
Crangon vulgaris.
†Hippolyte pusiola *Kr.*
†Diastylis lucifera.
† " sculpta? *G. O. Sars.*
†Pontoporeia femorata.
†Unciola irrorata *Say.*
†Amphithöe, *sp.*
†Ptilocheirus pinguis.
†Melphidippa, *sp.*
†Idotea phosphorea *Harger.*

TUNICATA.

*Eugyra pilularis *V.*
Pelonaia arenifera *St.*

MOLLUSCA.	
Pecten tenuicostatus *Migh.*	Petricola pholadiformis *Lam.*
Yoldia lmatula *Say.*	Mactra lateralis *Say.*
" sapotilla *Gould.*	Pandora trilineata? *Say.*
Nucula delphinodonta *Migh.*	Turbonilla interrupta *Totten.*
Astarte undata *Gould.*	Lunatia triseriata *Say.*
Cyprina Islandica *Linn.*	Nassa trivittata *Say.*
Cardium pinnulatum *Con.*	Buccinum undatum *Linn.*
Callista convexa *Say.*	Sipho pygmæus *Gld.*
	Bela cancellata *Migh.*

ART. XXVI.—*Notice of a new Fossil Spider from the Coal Measures of Illinois;* by O. HARGER.

Arthrolycosa antiqua*, gen. et sp. nov.

THE fossil spider, represented in the accompanying figure, was found by Mr. S. S. Strong, in one of the well known iron-stone concretions from Mazon Creek, Grundy County, Illinois, in "the lower part of the true Coal Measures," and is now preserved in the Museum of Yale College. The specimen, as seen upon the fractured surface of the concretion, presents for examination only the dorsal surface, and the other half of the concretion, or the cover, adds little or nothing to the knowledge of the fossil.

The outline of the cephalothorax in the specimen is indistinct, but measures about 10^{mm} (·4 in.) in length by 9^{mm} (·35 in.) in breadth. Near its anterior margin is a tubercle, which seems to present traces of a median longitudinal division, as if a pair of oval eyes had occupied its lateral portions. Behind this tubercle and near the middle of the cephalothorax is a pit or impression in the surface, and a little posterior to this a transverse ridge, somewhat convex forward. Other depressions and irregularities upon the surface seem to be unsymmetrical, and are probably accidental, or perhaps evidence that it has been flattened from an originally convex form. In front of the cephalothorax are two short, stout, divergent organs, apparently the mandibles, only one of which is shown in the figure. Upon the upper interior surface of the left mandible are two shallow longitudinal grooves, separated by a narrow rounded ridge. On the left side of the cephalothorax, and behind the mandible, are four appendages, probably the palpus and the first three legs, the fourth leg on the left side being absent. The first of these four appendages shows, in connection with the cephalothorax, two segments and a part

* From ἀρθρον, *a joint*, and λύκος, *a spider*, referring to the segmentation of the abdomen.

of a third. The first two of these segments are about equal in length, but the third is broken near its proximal articulation, and the connection of this appendage with what seems to be its distal cheliform segment is unfortunately imperfect. This segment is also poorly preserved, and the articulation of its digit is only to be seen with a good magnifier and in a certain light. The length of this segment is 5·5^{mm} (·22 in.); greatest breadth, 1·5^{mm} (·06 in.); length of digit, ·4^{mm} (·15 in.). I do not, however, consider the forcipulate character of this segment beyond a doubt. It is perhaps not improbable that it may have been modified much as in the males of ordinary spiders, and not truly forcipulate. The next appendage on the left side, which I have considered the anterior leg, presents a long, pretty well defined segment, doubtless the third or femoral segment, and traces of its proximal as well as its distal articulation, beyond which two other shorter segments are but poorly preserved. as shown in the figure. The next leg shows only the long or femoral segment, with indications of the trochanter, and the third leg on this side is even less well preserved. I suppose the fourth leg on this side to be entirely wanting.

On the right side of the specimen, immediately to the right of the mandible, the margin of the cephalothorax presents an elevation, and there is apparently nothing but the very base of the right palpus remaining. Two segments of the first leg are preserved, the first being much the longer; the second leg is preserved in a similar manner, and the third also. The first segment of the fourth leg on this side has been much flattened by pressure. On the surface of its posterior portion are a number of minute pits or depressions, the larger of which are represented in the cut. The same structure may be seen in a much less degree upon the third leg of the same side, and traces of it may be observed upon one or two of the other appendages. Another portion of the fourth leg of the right side is perhaps preserved in what appears to be a segment, or parts of two segments, a short distance to the right of and behind the end of the first segment, and not shown in the figure.

The abdomen consists of seven segments, the first being short and the last two short and somewhat indistinct. Its length equals that of the cephalothorax, 10^{mm} (·4 in.), its greatest breadth, 6·5^{mm} (·25 in.), breadth at union with cephalothorax, 4^{mm} (·15 in.). Two longitudinal grooves inclosing a long oval area near the middle of the anterior part of the abdomen, and of about half its length seem to have been caused by pressure, and the upper surface of the abdominal segments was probably in life smooth, as I see no evidence of the presence of hairs, tubercles, pits or grooves, nor of abdominal appendages of any kind, and the irregularities presented by the specimen appear

to be owing to the accidents of its preservation. The presence or absence of spinnerets cannot be determined.

In considering the relations of this insect to previously known living and fossil forms, the more important points of structure to be regarded are, the segmentation of the abdomen and its union with the cephalothorax, the character of the palpi, the position and number of the eyes, and the cephalothoracic pit.

The segmented character of the abdomen seems to be beyond a doubt. Mr. J. H. Emerton, in a letter to Prof. Marsh, has called attention to an aberrant spider described by Schiödte, under the name of *Lipistius desultor*,* in which the abdomen is destitute of spinnerets and furnished above with a series of nine horny plates. The abdomen of *Lipistius* would doubtless, under similar circumstances, bear a considerable resemblance to that of *Arthrolycosa*, and it is perhaps not impossible that the segmented appearance in the fossil may have been produced by a similar cause. The difference in the number of such plates would probably be a matter of comparatively slight structural importance. There seems, however, no good reason for explaining the apparent segmentation of the abdomen in the fossil by any other than the most natural and obvious cause, namely, that it was actually segmented in its structure. The small number of abdominal segments, apparently only seven at most, is an interesting point. If its segmented character is, as has been suggested by Mr. Scudder and others, to be considered a synthetic or embryonic feature, it would indicate in this early form the partial atrophy of the post-abdomen as in the true spiders, where, as has been shown by Claparède for the genus *Pholcus*, there are only five embryonic abdominal rings.

Unfortunately, in his description of *Protolycosa anthracophila*,† Römer does not state distinctly whether the abdomen is segmented or not. His figures indistinctly indicate nine or ten segments in its abdomen, while in the discussion of its zoölogical affinities, he implies that the abdomen was not segmented and even more directly in the statement, "Von dem Vorkommen ächter Spinnen mit ungegliedertem Hinterleib (*Araneæ*) in älteren Schichten lagen * * * * * bisher nur ganz unsichere oder unvollständige Angaben vor." The specimen presents no traces of the peculiar abdominal appendages of *Protolycosa*, nor of the circular opening at the extremity of the abdomen, nor of transverse rows of tubercles. There seems to be no good evidence that the union of the cephalothorax and abdomen was as delicate as in ordinary

* Naturhistorisk Tidsskrift, II, vol. ii, p. 617, pl. v, 1849.

† Neues Jahrbuch für Mineral. Geol. u. Palæont. von Leonhard u. Geinitz, p. 136, pl. III. Stuttgart, 1866.

spiders; the two were, however, well separated, and doubtless by a more decided constriction than appears in the specimen, thus differing from the fossil genera *Architarbus** and *Eophrynus*† and resembling *Protolycosa*.

The palpi in this specimen must be considered as absent on both sides unless the first appendage exterior to the mandible on the left side be regarded as a palpus, as seems to be the fact. The segments of this appendage do not correspond with those of the legs, as shown by the description and figure, the first two visible segments being of about equal length instead of the first being much the longer, as in the legs. The claw or hand at the extremity of this appendage is, as I have said, poorly preserved, but if a forcipulate structure existed at all, it is as distinct as in the false scorpions, and much more pronounced than in *Protolycosa*, where "the last segment of the left palpus appears to be divided by an incision at its extreme end." The presence of well developed forcipulate palpi in *Arthrolycosa* would indicate affinity with the false scorpions, or perhaps, as Prof. Verrill suggests, with *Thelyphonus*. The fossil, however, presents no trace of the long caudal stylet present in that genus. If the appendage in question be a palpus its size alone would point toward affinity with the lower arachnids (*Solpugidae*, *Phrynus*); if it be a leg, then the palpi were doubtless small as in most spiders, since little room is left for their articulation.

The tubercle upon which the eyes were probably situated seems a character indicative of affinity with the lower arachnids, where, as especially among the *Phalangidæ* and scorpions such a structure is common, although it may occur among true spiders, as in *Lipistius*. It is impossible to determine whether eyes existed upon other parts of the cephalothorax or not, and there is no reason for supposing their absence except such as may be drawn from the presence of an oculiferous tubercle. Unfortunately the eyes of *Protolycosa* have not been made out, but the cephalothorax of that fossil seems to have been destitute of a tubercle. This, together with the difference in the abdomen already mentioned, must be regarded as furnishing diagnostic characters of at least generic importance, to which may be added the cephalothoracic pit in *Arthrolycosa*. The mandibles resemble those of *Protolycosa*, and probably did not differ greatly from those of the true spiders.

I would not, however, refer *Arthrolycosa* to the true spiders, but consider it as representing a group of insects combining features now characteristic of separate groups and of embryonic states. The family which may be called the *Arthrolycosidæ* seems to have borne relations to the *Phalangidæ* and scorpions in its oculiferous tubercle, and to the latter group as well

* S. H. Scudder, Geol. Surv. Illinois, vol. iii, p. 568, fig. 4, 1868.
† H. Woodward, Geol. Mag., vol. viii, p. 385, pl. xi. London, Sept. 1871.

as the false scorpions and *Thelyphonus* in its forcipulate palpi. The union of the cephalothorax and abdomen appears to have been much as in *Thelyphonus*, although perhaps resembling that seen in the spiders, and as Mr. Scudder has suggested, separates the group from that to which *Architarbus* belongs, while it is allied to the lower arachnids in general and to the embryonic forms of the true spiders in its segmented abdomen. The general form of the insect is also much like that of the true spiders, among which the *Mygalidæ* have been mentioned by Mr. Emerton as near allies. The oculiferous tubercle and the cephalothoracic pit appear to sustain this opinion and if the examination of additional material should show that the palpi are not forcipulate, but are small and absent from this specimen, we should have in the *Arthrolycosidæ*, an interesting example of what might properly be called an embryonic type.

The thanks of the author are due to Prof. O. C. Marsh, and through him to Mr. S. H. Scudder and Mr. J. H. Emerton, for the kindly interest that these gentlemen have manifested, and for their valuable suggestions upon the literature of the subject and the affinities of the insect.

Yale College, New Haven, Feb. 9th, 1874.

Art. XXVII.—*On some Crystals of Zinc;* by S. P. Sharples, S.B.

(Read before the American Academy, Jan. 13, 1874.)

Some years ago M. G. Farmer, of Boston, constructed a number of thermo-electric batteries, using an alloy of zinc and antimony for one of the elements, and German silver for the other.

The alloy of zinc and antimony contained about fifty per cent of each metal, an analysis giving 50·7 per cent of zinc. One of these batteries was kept constantly heated for upward of a year, and upon breaking it up the end of the zinc-antimony elements furthest from the point to which the heat was applied, were found to be covered with a moss-like growth of metal.

This moss was found under the microscope to consist of flat ribbon-like crystals, which were deeply striated in the direction of their length. Analysis gave ninety-eight per cent of metallic zinc. They are very tough and will bear a considerable amount of bending, while the alloy itself is as brittle as glass.

Prof. Cooke, in some experiments with zinc and arsenic, made some years ago, obtained similar crystals by subliming zinc in a closed tube, and I have observed these crystals in the prolonges of the zinc works in South Bethlehem, Penn. But

in both these instances the zinc has been deposited from the vapor of metallic zinc, while in the other case the heat has not been great enough to even melt the asphaltum varnish with which the end of the element is covered. Cases of molecular re-arrangement are frequent, when this change takes place in the interior of a solid mass, but I have never before met with a case in which one metal was separated from another by such change and projected beyond the surface of the alloy.

SCIENTIFIC INTELLIGENCE.

I. Chemistry and Physics.

1. *On the hydrocarbon Fluorene.*—This hydrocarbon was discovered by Berthelot in 1867, in that portion of coal-tar volatile between 300° and 340°. Barbier has recently submitted it to a more extended investigation. He prepared it by Berthelot's method, except that, instead of crystallizing the fraction distilling between 300° and 305° from alcohol alone, a mixture of alcohol and benzine was used, by which a small quantity of acenaphtene is separated. When pure, fluorene has a well pronounced violet fluorescence, which disappears on solarization. It fuses at 113°. The formula $C_{13}H_{10}$ was established for it: (1) by an elementary analysis; (2) by an analysis of the picrate, in which not only were the picric acid and the hydrocarbon determined, but also the carbon and the hydrogen; and (3) by a complete analysis of a well-defined bromide. The picrate crystallizes in fine red needles, fusing at 80°–82°, and has the formula $C_{13}H_{10}, C_6H_3(NO_2)_3O$. The bromide crystallizes in magnificent clinorhombic tables, fusible at 166°–167°, and has the formula $C_{13}H_8Br_2$. When heated to redness in presence of lime, the bromide yields a lamellar mass fusible at 100°, and being apparently diphenyl. If so, fluorene has the constitution of diphenylmethylene, $C(C_6H_5)_2$. When treated with an acetic acid solution of chromic acid, it yields an oxidation-product crystallizing in fine yellow needles, the character of which the author is now studying.—*C. R.*, lxxvii, 44[illegible], Aug., 1873. G. F. B.

2. *On Nitroanthracene and its Derivatives.*—More than a year ago, Schmidt announced that mono-nitranthracene yielded, on reduction with tin and hydrochloric acid, not anthracene itself but an isomer of it. He has now still farther examined this substance. Its fusing point (247°), so near that of para-anthracene (244), suggests its identity with this body. But that this cannot be appears from several facts. First, while para-anthracene by heat passes readily into anthracene, its fusing point falling to 213°, the new isomer may be repeatedly fused and even heated to 300° without any change in its fusing point. Moreover, its picrate, which is formed less easily than the similar anthracene compound,

crystallizes in beautiful red needles often an inch long. Upon analysis, however, they give the formula $C_{14}H_{10}$, $C_6H_2(NO_2)_3$ OH. Nitric acid, boiling, converts the new hydrocarbon into a yellow nitro-product, $C_{14}H_9(NO_2)$, without a trace of a quinone. This nitro-product sublimes in beautiful pale yellow needles, which fuse at 209°. These reactions distinguish the new body sufficiently from anthracene on the one hand and para-anthracene on the other. Bromine yields with it a condensation product $C_{28}H_{19}Br_3$, fusing at 273°, subliming without decomposition and being unattackable by potassium hydrate. Very careful oxidation by means of chromic acid yields a quinone which has the formula $C_{14}H_8O_2$, which sublimes and crystallizes in magnificent red needles, fusing at 235°. Concentrated sulphuric acid dissolves this quinone with a splendid indigo-blue color; a very delicate test for it. Water separates the unaltered quinone from the solution. Sulphurous acid converts it into a colorless hydroquinone, which oxidizes readily in the air. Distilled with soda-lime, a hydrocarbon is produced which has not been yet studied.—*Ber. Berl. Chem. Ges.*, vi, 494, 1873. G. F. B.

3. *A new Synthesis of Glycocoll.*—Emmerling has succeeded in effecting a new synthesis of glycocoll which is not only remarkable as a synthetic result of great importance, but also as illustrating certain fundamental points in chemical theory. Starting from the fact that hydrogen iodide is capable of exerting upon organic bodies a double action; that it can not only reduce them to the saturated hydrocarbon from which they are derived, but can also cause them by assimilating water to split up into two or more molecules, Emmerling advanced to his synthesis. The method was simple; cyanogen gas was passed through a concentrated solution of hydrogen iodide. One of the cyanogen atoms in the molecule, by hydrogenation, became the methylamine residue CH_2NH_2; the other, by exchanging its nitrogen for the elements of water, gave rise to a carboxyl group, COOH. The formation of glycocoll therefore takes place according to the following equation:—

$$\begin{matrix}CN\\|\\CN\end{matrix} + (HI)_5 + (H_2O)_2 = \begin{matrix}CH_2NH_2\\|\\COOH\end{matrix} + NH_4I + I_4.$$

The yield is considerable and the properties of the glycocoll are identical with those of that of organic origin. The author thinks this result goes far to prove that the reason why uric acid yields glycocoll by treatment with HI, is because it contains a cyanogen molecule; in opposition to the view of Strecker, that the glycocoll existed partially preformed in the uric acid.—*Ber. Berl. Chem. Ges.*, vi, 1351, Dec., 1873. G. F. B.

4. *On an Isomer of Alizarin, Quinizarin.*—Grimm has recently confirmed the statement of Baeyer, that, like the other phenols, hydroquinone combines directly with phthalic acid. He finds, however, that, when the two are warmed to 130°–140° with concentrated sulphuric acid, two bodies are formed; one the phthalein of hydroquinone, which is colorless and resembles

closely the phthalein of phenol; the other a red coloring matter, an isomer of alizarin—to which Grimm gives the name quinizarin—which unfortunately is produced in very small quantity, only 1–2 per cent of the theoretical yield. It is prepared by treating the mass as above obtained with absolute alcohol and then precipitating with water; or by solution in benzole, which dissolves the quinizarin, leaving the phthalein. Recrystallization from alcohol and ether afford it pure, and it then has the composition $C_{14}H_8O_4$. It is produced according to the equation:

$$C_8H_4O_3+C_6H_6O_2=C_{14}H_8O_4+H_2O.$$

From ether it crystallizes in yellow plates, from benzole and alcohol in deep red needles. Water throws down yellowish red flocks, which become crystalline on heating. The etherial and sulphuric acid solutions show a greenish-yellow fluorescence. The former shows a brownish yellow color by transmitted light, the latter a peculiar violet, passing by dilution into a bright onion-red. This suggests its possible relations with munjustin. Alkalies dissolve quinizarin to a deep blue color. Since anthracene results when its vapor is passed over heated zinc dust, Grimm suggests its close similarity with alizarin, and proposes for it the rational formula

$$C_6H_4\begin{matrix}-CO-\\-CO-\end{matrix}C_6H_2(OH)_2.$$

—*Ber. Berl. Chem. Ges.*, vi, 506, 1873. G. F. B.

5. *The Horizontal Pendulum.*—Zöllner describes a series of experiments with a form of horizontal pendulum of such surprising delicacy that it seems to open a wide and fruitful field for investigation. This instrument consists of a short horizontal rod suspended by a vertical piece of fine watch-spring, and carrying at one end a heavy leaden weight and mirror. To prevent the other end from rising, a second watch-spring is attached, and fastened below. The two points of support lie therefore nearly in the same vertical, and are equidistant, one above and the other below, the pendulum. They are connected with the top and bottom of a vertical rod, which rests on a tripod, with leveling screws. If the two points lie in the same vertical, the weight will remain in any position; but if one of the leveling screws is slightly moved, the pendulum will assume a position of equilibrium around which it will vibrate, if disturbed. It will act, in fact, precisely like a common pendulum, except that the effect of gravity has been greatly diminished, so that the time of vibration is increased. Its sensibility is of course readily varied by shifting the levelling screw. In the instrument actually employed, the pendulum weighed about six pounds, and when removed from its supports and vibrated vertically like a common pendulum, its time of oscillation was about ·25 of a second. The springs were about eight inches long and the delicacy of the instrument was such that its vibrations were easily observed when the time was increased to thirty seconds, corresponding to a diminution of the force of gravity of fourteen thousand times. In the actual experiments a time of vibration of

14·44 seconds was employed. The motions were observed by viewing the reflections of a scale at a distance of 3168^{mm} from the mirror. The whole instrument was mounted on a stone pier and protected with great care from air currents, or changes of temperature. The instrument was so susceptible to disturbing influences, that it was set in motion by a railway train passing at a distance of about a mile.

Any change in the direction of the force of gravity would produce a corresponding motion of the pendulum, and in the present case a change of ·001 of a second of arc would be perceptible, or would alter the scale-reading ·1 of a millimeter. Now the calculations of Dr. C. A. F. Peters show that the effect of the moon when at its maximum produces a deviation of ·0174″, or doubling this amount for the difference on the two sides of the meridian ·035″, or thirty-five times the amount perceptible with this instrument. The sun in like manner would produce a variation of ·016″. Hence it seems possible by this means to weigh directly the masses of the sun and moon in terms of the earth, and hence determine their distances. The deviation would change its sign whenever these bodies crossed the meridian, and hence if it could be accurately determined, would afford a means of measuring the time required by gravity to pass from the sun to the earth. Of course, such observations would be greatly disturbed by variations of temperature, shaking of the ground, and many other causes; and hence should be conducted in caves at a considerable distance from human habitation.—*Pogg. Annal.*, cl, 134. E. C. P.

6. *Specific heat of Gases under constant volume and under constant pressure.*—M. Amagat has measured that most important constant, the ratio of the two specific heats of gases, as follows. The simplest method would be that of MM. Clément and Desormes, were it not for the oscillation of the gaseous mass at the orifice, discovered and studied by M. Cazin. This complication is avoided by the method here employed, which consists in compressing a limited volume of the gas, at the pressure of the atmosphere, and determining its pressure immediately after its reduction in volume. The initial and final volume being determined without difficulty, it only remains to apply the formula of Poisson, $pv^{\frac{C}{c}}=p'v'^{\frac{C}{c}}$, in which the exponent $\frac{C}{c}$ is the unknown quantity.

It appeared at first difficult to determine almost instantly with a manometer the pressure of a gas which began immediately to cool. It was easily done, however, by the following method.

The gaseous mass, immediately after compression, was, by opening a stopcock, put in communication with a manometer of oil, previously set at a pressure a little less than that sought; so that the ascent of the manometric liquid was very slight. Closing the stopcock the manometer remained more nearly at the right height than before. Repeating this operation several times, the manometer at length remained stationary at the instant when the stopcock

was opened, and marked then the desired pressure. This pressure was now determined by connecting a mercury manometer with the oil.

The compression of the gas was effected by a column of mercury rising rapidly in a large tube, which formed the prolongation of the neck of the flask in which the gas was enclosed. The pressure was communicated to the mercury by a layer of oil driven by a piston fitting into a copper cylinder. The heat which would be developed by friction if the piston compressed the gas directly was thus avoided; the compression was easily effected in half a second and the results were very concordant. The amount of the compression never exceeded three centimeters, and in the last series of observations, the greatest deviation from the mean was only a tenth of a millimeter.

By studying the descending motion of the manometer after the compression it was found that a slight correction could be applied for the lowering of the temperature of the gas during compression. Without the correction, for atmospheric air $\frac{C}{c}=1{\cdot}391$, and applying the correction $\frac{C}{c}=1{\cdot}397$.

It is evident, further, that we can avoid, or at least greatly diminish, the effect of cooling, by employing a large reservoir; the flask here used having a volume of scarcely twenty liters.

From the preceding result we deduce for the mechanical equivalent of heat the number 434, which differs only by a single unit from that recently found by M. Violle with Foucault's apparatus. An experiment with carbonic acid gave the results $\frac{C}{c}=1{\cdot}299$; an accident happening to the apparatus interrupting the study of this gas. There is reason to believe that this result is a little too great; moreover the gas was not entirely free from air.—*Comptes Rendus*, lxxvii, 1325. E. C. P.

7. *Relative intensity of the constituent rays of various sources of light.*—M. Trannin describes a form of photometer for comparing the intensity of the various simple colors of which every light is composed. It consists:—

(1.) Of two small right-angled prisms, placed one above the other and turned in opposite directions, so as to receive the rays from two sources of light placed opposite each other.

(2.) These prisms are placed in front of a narrow slit whose height is thus divided into two halves unequally illuminated. The light then enters a collimater by which it is rendered parallel, next a polarizer whose principal section is vertical, and then a plate of quartz about a centimeter thick, cut parallel to the axis and whose principal section makes an angle of 45° with that of the polarizer; finally, through an analyzer, having its principal section vertical, formed of a double image prism.

(3.) The dispersive prism and telescope of a spectroscope finally receive the luminous rays.

The double image prism doubling both rays makes the ordinary ray from one source coincide with the extraordinary ray from the other. But in general each of the elementary rays emerging from the plate of quartz is polarized elliptically, and we know that this kind of light after having traversed any doubly-refracting analyzer gives two images of unequal intensity polarized at right-angles, but whose sum is constant and equal to the sum of the squares of the velocities parallel to the two axes of the ellipse. The beam, after traversing the double-image prism, will then give a spectrum formed of three horizontal bands, in the field of the telescope. That in the center is due to the superposition of the extraordinary ray from one part of the slit, on the ordinary ray from the other part, and is consequently continuous, or as if it was completely unpolarized, if the two parts are equally illuminated. Above and below will be spectra traversed with bands, the dark spaces of one corresponding to the light ones of the other.

To make the observation, therefore, one of the lights must be diminished until the bands completely disappear from the central spectrum. This is accomplished by either withdrawing one of the sources of light, or by interposing a Nicol's prism between the eye and eye-piece, which may be turned through any desired angle. — *Comptes Rendus*, lxxviii, 1497. E. C. P.

8. *The Selection and Nomenclature of Dynamical and Electrical Units.**—We consider that the most urgent portion of the task entrusted to us is that which concerns the selection and nomenclature of units of force and energy; and under this head we are prepared to offer a definite recommendation.

A more extensive and difficult part of our duty is the selection and nomenclature of electrical and magnetic units. Under this head we are prepared with a definite recommendation as regards selection, but with only an interim recommendation as regards nomenclature.

Up to the present time it has been necessary for every person who wishes to specify a magnitude in what is called "absolute" measure, to mention the three fundamental units of mass, length, and time, which he has chosen as the basis of his system. This necessity will be obviated, if one definite selection of three fundamental units be made once for all, and accepted by the general consent of scientific men. We are strongly of opinion that such a selection ought at once to be made, and to be so made that there will be no subsequent necessity for amending it.

We think that, in the selection of each kind of derived unit, all arbitrary multiplications and divisions by powers of ten, or other factors, must be rigorously avoided, and the whole system of fundamental units of force, work, electrostatic, and electromagnetic elements, must be fixed at one common level—that level, namely, which is determined by direct derivation from the three fundamental units once for all selected.

The carrying out of this resolution involves the adoption of

* First Report of the British Association Committee on Units.

some units which are excessively large or excessively small in comparison with the magnitudes which occur in practice; but a remedy for this inconvenience is provided by a method of denoting decimal multiples and sub-multiples, which has already been extensively adopted, and which we desire to recommend for general use.

On the initial question of the particular units of mass, length, and time, to be recommended as the basis of the whole system, a protracted discussion has been carried on, the principal point discussed being the claims of the gram, the *meter* and the second, as against the gram, the *centimeter*, and the second; the former combination having an advantage as regards the simplicity of the name *meter*, while the latter combination has the advantage of making the unit of mass practically identical with the mass of unit volume of water; in other words, of making the value of the density of water practically equal to unity. We are now all but unanimous in regarding this latter element of simplicity as the more important of the two; and in support of this view we desire to quote the authority of Sir W. Thomson, who has for a long time insisted very strongly upon the necessity of employing units which conform to this condition.

We accordingly recommend the general adoption of the centimeter, the gram, and the second, as the three fundamental units: and until such time as special names shall be appropriated to the units of electrical and magnetic magnitude hence derived, we recommend that they be distinguished from "absolute" units otherwise derived, by the letters "C. G. S." prefixed, these being the initial letters of the names of the three fundamental units.

Special names, if short and suitable, would in the opinion of most of us, be better than the provisional designations "C. G. S. unit of . . . . ." Several lists of names have already been suggested; and attentive consideration will be given to any further suggestions which we may receive from persons interested in electrical nomenclature.

The "ohm," as represented by the original standard coil, is approximately 10^9 C. G. S. units of resistance. The "volt" is approximately 10^8 C. G. S. units of electromotive force, and the "farad" is approximately $\frac{1}{10^9}$ of the C. G. S. unit of capacity.

For the expression of high decimal multiples and sub-multiples, we recommend the system introduced by Mr. G. J. Stoney—a system which has already been extensively employed for electrical purposes. It consists in denoting the exponent of the power of 10 which serves as multiplier, by an appended cardinal number if the exponent be positive, and by a prefixed ordinal number if the exponent be negative. Thus:—

10^9 grams constitute a *gram-nine*,

$\frac{1}{10^9}$ of a gram constitutes a *ninth-gram*.

The earth's circumference is approximately four meter-sevens, or four centimeter-nines.

For multiplication or division by a million, the prefixes *mega** and *micro* may conveniently be employed, according to the present customs of the electricians. Thus the *megohm* is a million ohms, and the *microfarad* is the millionth part of a farad. The prefix *mega* is equivalent to the affix *six*. The prefix *micro* is equivalent to the prefix *sixth*. The prefixes *kilo*, *hecto*, *deka*, *deci*, *centi*, *milli* can also be employed in their usual senses before all new names of units.

As regards the name to be given to the C. G. S. unit of force, we recommend that it be a derivative of the Greek δύναμις. The form *dynamy* appears to be the most satisfactory to etymologists. *Dynam* is equally intelligible, but awkward in sound to English ears. The shorter form *dyne*, though not fashioned according to strict rules of etymology, will probably be generally preferred in this country. Bearing in mind that it is desirable to construct a system with a view to its becoming international, we think that the termination of the word should, for the present, be left an open question. But we earnestly request that, whichever form of the word be employed, its meaning be strictly limited to the unit of force of the C. G. S. system; that is to say, the force which, acting upon a gram of matter for a second, generates a velocity of a centimeter per second.

The C. G. S. unit of work is the work done by this force, working through a centimeter; and we propose to denote it by some derivative of the Greek ἔργον. The forms *ergon*, *ergal*, and *erg* have been suggested; but the second of these has been used in a different sense by Clausius. In this case also we propose for the present to leave the termination unsettled; and we request that the word *ergon* or *erg* be strictly limited to the C. G. S. unit of work, or what is, for purposes of measurement, equivalent to this, the C. G. S. unit of energy, energy being measured by the amount of work which it represents.

The C. G. S. unit of power is the power of doing work at the rate of one erg per second, and the power of an engine (under given conditions of working) can be specified in ergs per second.

For rough comparison with the vulgar (and variable) units based on terrestrial gravitation, the following statement will be useful:—

The weight of a gram at any part of the earth's surface is about 980 dynes, or rather less than a kilodyne.

The weight of a kilogram is rather less than a megadyne, being about 980,000 dynes.

Conversely, the dyne is about 1·02 times the weight of a milligram at any part of the earth's surface, and the megadyne is about 1·02 times the weight of a kilogram.

The kilogram-meter is rather less than the erg-eight, being about 98 million ergs.

The gram-centimeter is rather less than the kilerg, being about 980 ergs.

* Before a vowel, either *meg* or *megal* (as euphony may suggest), may be employed instead of *mega*.

For exact comparison the value of g (the acceleration of a body falling in vacuo) at the station considered, must of course be known. In the above comparisons, it is taken as 980 C. G. S. units of acceleration.

One horse-power is about three quarters of an erg-ten per second. More nearly, it is 7·46 erg-nines per second, and one *force de cheval* is 7·36 erg-nines per second.

The mechanical equivalent of one gram-degree (centigrade) of heat is 41·6 megalergs or 41,600,000 ergs.*

[The *dyne* or unit of force which is proposed by the committee is to be a new unit of the same nature as a gram-weight, or the earth's attraction for a gram-mass, and having no commensurable ratio with it. Now our simplest and most useful ideas of force are derived at once from weight. It seems to us that, of necessity, this will always be the case. Probably the learned committee have no expectation that even among scientific men the new units will entirely replace what they call the vulgar ones. If, then, their recommendation is accepted, we shall create for certain departments of mechanical science new units of force and energy which are in no useful ratios to those used in other departments of science, and by people at large. Is there not some way of avoiding this great evil? Societies are formed and sustained whose main and most worthy object is to get rid of such confusions. We think the proposed units should be stoutly challenged to show a necessity for their being.

We do need, it may be added, a new *name* for the earth's attraction upon a gram of matter at some fixed place. The words *gram*, *pound*, *ton*, etc., have had to do service in two different senses, that is, as mass, and as force. If any good word could come into use that shall express the earth's attractive force for a gram of matter at some place that may be agreed upon, it would meet a real want.—H. A. N.]

II. Geology and Natural History.

1. *Some of the Geological views of Hutton.*—The following paragraphs are cited from an Inaugural Lecture by Archibald Geikie, Professor of Geology and Mineralogy in the University of Edinburgh. 1871.—Hutton felt, as Steno and Moro had done, that the earthquake and volcano were but parts of the general mechan-

* Mr. Stoney, who is a member of the Committee, urges the meter instead of the centimeter as the unit of length to serve as base of the system. He says the centimeter "is far too small, and its multiples and submultiples cannot be briefly designated. From its being too small, it, in conjunction with the gram and second, lands us in quite out-of-the-way mechanical units—the unit of force which results being but little more than the pressure of a milligram, and the unit of work being but little more than the hundred thousandth part of a grammeter. This I deem a very serious objection.

"I still think that these awkward consequences, and the footing which the meter has already gained in science, will prove fatal to the recommendation of the Committee, and that experience will show that the meter must in the end be accepted as the standard unit of length."

ism of our planet. But he saw, also, that they were not the only exhibitions of the potency of subterranean agencies, that, in fact, they were only partial and perhaps even secondary manifestations of the influence of the great internal heat of the globe, and that the full import of that influence could not be understood unless careful study were given also to the structure of the rocky crust of the earth. Accordingly he set himself for years patiently to gather and meditate over data which would throw light upon that structure and its history. The mountains and glens, river-valleys and sea-coasts of his native country, were diligently traversed by him, every journey adding something to his store of materials, and enabling him to arrive continually at wider views of the general economy of nature. At one time we find him in a Highland glen searching for proofs of a hypothesis which he was convinced must be true, and, at their eventual discovery, breaking forth into such gleeful excitement that his attendant gillies concluded he must certainly have hit upon a mine of gold. At another time we read of him boating with his friends Playfair and Hall along the wild cliffs of Berwickshire; again, in search of confirmation to his views, and finding, to use the words of Playfair, "palpable evidence of one of the most extraordinary and important facts in the natural history of the earth."

As a result of his wanderings and reflection, he concluded that the great mass of the rocks which form the visible part of the crust of the earth was formed under the sea, as sand, gravel, and mud are laid down there now; and that these ancient sediments were consolidated by subterranean heat, and, by paroxysms of the same force, were fractured, contorted, and upheaved into dry land. He found that portions of the rocks had even been in a fused state; that granite had been erupted through other stony masses; and that the dark trap-rocks, or "whinstones" of Scotland, were likewise of igneous origin. * * * *

Hutton maintained that the combined influence of subterranean heat and pressure upon sedimentary rocks could consolidate and mineralize them, and even convert them into crystalline masses. He was thus the founder of the modern doctrines of metamorphism regarding the gradual transformation of marine sediments into the gnarled and rugged gneiss and schist of which mountains are built up. Let me quote the eulogium passed upon this part of his work in an essay by M. Daubrée, which eleven years ago was crowned with a prize by the Academy of Sciences at Paris:—"By an idea entirely new, the illustrious Scottish philosopher showed the successive coöperation of water and the internal heat of the globe in the formation of the same rocks. It is the mark of genius to unite in one common origin phenomena very different in their nature." "Hutton explains the history of the globe with as much simplicity as grandeur. Like most men of genius, indeed, who have opened up new paths, he exaggerated the extent to which his conceptions could be applied. But it is impossible not to view with admiration the profound penetration and the strict-

ness of induction of so clear-sighted a man, at a time when exact observations had been so few, he being the first to recognize the simultaneous effect of water and heat in the formation of rocks, in imagining a system which embraces the whole physical system of the globe. He established principles which, in so far as they are fundamental, are now universally admitted." * * * *

Hutton first caught the meaning of that constant circulation of water which, by means of evaporation, winds, clouds, rain, snow, brooks, and rivers, is kept up between land and sea. He saw that the surface of the dry land is everywhere being wasted and worn away. The scarped cliff, the rugged glen, the lowland valley, are each undergoing this process of destruction; wherever land rises above ocean, there, from mountain-top to sea-shore, degradation is continually going on. Here and there, indeed, the débris of the hills may be spread out upon the plains; here and there, too, dark angular peaks and crags rise as they rose centuries ago, and seem to defy the elements. But these are only apparent and not real exceptions to the universal law, that, so long as a surface of land is exposed to the atmosphere, it must suffer disintegration and removal.

But Hutton saw, further, that this waste is not equally distributed over the whole face of the dry land. He perceived that while, owing to the greater or less resistance offered by different kinds of rocks, the rate of decay must vary indefinitely, the amount of material must necessarily be greatest where the surplus water flows off toward the sea, that is, along the channels of the streams. Water-courses, he argued, are precisely in the lines which water would naturally follow in running down the slope of the land from its water-shed to the sea, and which, when once selected by the surplus drainage, would necessarily be continually widened and deepened by the excavating power of the rivers. Hence he regarded the streams and rivers of a country as following the lines which they had chiselled for themselves out of the solid land; and thus he arrived at the deduction that valleys have been, inch by inch and foot by foot, dug out of the solid framework of the land by the same natural agents—rain, frost, springs, rivers—by which they are still made wider and deeper. "The mountains," he said, "have been formed by the hollowing out of the valleys, and the valleys have been hollowed out by the attrition of hard materials coming from the mountains." This is a doctrine which is only now beginning to be adequately realized. Yet to Hutton it was so obvious as to convince him, to use his own memorable words, "that the great system upon the surface of this earth is that of valleys and rivers, and that, however this system shall be interrupted and occasionally destroyed, it would necessarily be again formed in time, while the earth continued above the level of the sea."

2. *On the Topography and Geology of Santo Domingo;* by WILLIAM M. GABB. 260 pp. 4to, with a map. From the Transactions of the American Philosophical Society, vol. xv.—Mr. Gabb

here presents the results of his investigations during three years residence in San Domingo, comprising facts relating to the topography and geology of 15,000 square miles, or about half the island. He states that the only fossiliferous rocks of the island, besides the Quaternary, are the Cretaceous, which are all more or less metamorphic, and the Tertiary. Along the central portions of the island there are crystalline rocks, which he groups under the generic term of *Syenite*, since they almost invariably consist of the three essential minerals, quartz, feldspar and hornblende. They are pronounced intrusive. Flanking the Cretaceous slates, etc., of the Sierra, there is a broad development of Tertiary along the northern, and part of the southern, side of the island.

The metamorphic rocks referred to the Cretaceous are much upturned and folded, the axes of the folds usually east and west, or parallel with the axis of the mountains. The rocks include, besides the common slates, semi-talcose in aspect, thick strata of sandstones, limestones and conglomerates; but, owing to the disturbed condition of the whole, and the partial obliteration of the bedding in some cases, the order of stratification has not been made out. The reference of them to the Cretaceous is sustained by the discovery, at a few points, of species of *Ostrea*, *Trigonia*, *Ammonites*, and some other genera, which appear to be of Cretaceous character.

The Tertiary of the island is referred to the Miocene period; about thirty per cent of the shells belong to living species. The beds in general lie nearly horizontally over the Cretaceous, but in some places are highly tilted. In the middle of the Santiago valley the height of the beds—there horizontal—is about 200 feet, and, in the hills south of Samana bay, 300 to 400 feet; but, further north, they have been elevated along a line a hundred miles in length, with some upturning, to a height in some cases of 3000 feet or more, "making the Monte Christi Chain, where, until the end of the Miocene, had been a level sea-bottom, covered with white calcareous mud." A large number of Miocene fossils are described by Mr. Gabb. In connection with the account of the Quaternary, Mr. Gabb describes a chalk-like rock, which is of Coral origin. As it is not derived from the accumulation of Rhizopods, like true chalk, he has named the soft rock *Antillite*. The above are a few facts from this important memoir.

3. *Trachytic and doleritic rocks in alternations in the Puebla Range of mountains, in the northern part of Humboldt county, Nevada;* by JAMES BLAKE, M.D.—Dr. Blake describes the Puebla Mountains as consisting of an eastern ridge of upturned metamorphic rocks, having the strike N. 16° E. and dip 78° to the eastward; and a western ridge formed of beds of eruptive rocks dipping 20° to the westward. The latter are all conformable from the base to the summit, 1200 feet above, and vary in thickness from 20 to 50 or more feet. The eruptions are stated by Dr. Blake to be probably early Miocene. The rocks of the beds are of both the doleritic and trachytic kinds. They include the varieties of

dolerite, called basalt and anamesite, the chrysolitic kind or peridotite, and the chloritic kind called diabase; and, in alternations with these, trachyte; and toward the top vesicular trachyte and porphyritic obsidian. In a porphyritic dolerite the crystals of labradorite are an inch long, and often twins; and the augite is sometimes in crystalline plates. Magnetite is present in most of the rocks in minute grains or crystals. Several of the rocks have been analyzed: the porphyritic dolerite afforded 49 per cent of silica; the anamesite, 44 per cent; the diabase, 51 per cent; the green trachyte, 72 per cent. Dr. Blake concludes from the facts that the views of Richthofen with regard to the relative ages of the different kinds of eruptive rocks will not apply to those of the Puebla Mountains.

Dr. Blake further states that the valley between the two ridges of the Puebla Range has suffered much erosion, and that at one time it must have been filled by a vast glacier which flowed out over the southern part of the eastern range, and left a moraine 250 feet thick, that extends a mile and a half into the plain beyond the base of the mountain.—*Proc. Calif. Acad. Sci.*, v, 210.

4. *Bulletin of the United States Geological and Geographical Survey of the Territories.* Department of the Interior. No. I. 28 pp. 8vo. Washington, 1874.—The Department of the Interior has adopted the excellent plan of issuing in parts, called Bulletins, special portions of the coming Annual Report of the Geological and Geographical Survey of the Territories—the survey now carried forward by F. V. Hayden as U. S. Geologist in charge, and J. T. Gardner, Geographer. This first number of the series, after giving a list of the officers of the expedition for the past year, and another of former publications by the Survey, presents a Report by E. D. Cope "on the Stratigraphical relations and Vertebrate paleontology of the formations which represent the Pliocene epoch in Northeastern Colorado." This Report enumerates the species of Pliocene vertebrates observed in Colorado by the author, during the year 1873, and gives descriptions of the larger part of them. They include 4 Carnivores; 7 Perissodactyls (2 species of *Aphelops*, 2 of *Hippotherium*, 3 of *Protohippus*); 7 of Artiodactyls (2 of *Merichyus*, 4 of *Procamelus*, 1 of *Merycodus*); the Proboscidian, *Mastodon proavus* Cope (of the type of the *Mastodon Americanus*); and the Testudinate, *Stylemys? Niobrarensis* Leidy. Next follow short notes on other Tertiary Mammals from Colorado: *Menotherium lemurinum* Cope, supposed to be allied to the Lemurs, *Isacis caniculus* Cope, *Hoplophoneus* (*Machærodus*) *oreodontis* Cope, *Poëbrotherium Hallii* Leidy, *P. Wilsonii* Leidy; species of *Hypisodus*, *Hypertragulus*, *Leptomeryx*, *Elotherium* and *Symborodon*. Cope announces that the Pliocene camels of the Rocky Mountain region had a full set of upper incisors.

We have received the following from Dr. Hayden with regard to Bulletin No. 2, which will soon be issued: This number contains a long article by Prof. Cope on the relation of the Cretaceous

and Tertiary formations of the West, as indicated by their vertebrate remains, and another on new species of fossil fishes from the Cretaceous of Kansas and the Tertiary of Colorado; an article by Prof. Thomas on new species of Acrididæ; and a paper by Mr. J. T. Gardner on the principal ranges of Mountains surveyed by the party last summer in Colorado, with the elevations and the longitude and latitude of the most prominent peaks, varying from 13,000 to 14,600 feet above sea level. The final maps of the expedition up Snake River, and in Montana, during the year 1872, are now engraved on a scale of five miles to one inch; they will be published both as topographical and geological maps. Maps of the Upper and Lower Geyser Basins, which were carefully surveyed, are engraved on a scale of eight inches to one mile.

5. *The Abrasions of the Continental Shores of Northwest America, and the supposed Ancient Sea Levels;* by GEORGE DAVIDSON (Proc. Calif. Acad. Sci., May 5, 1873).—Mr. Davidson has here brought together many interesting facts with regard to plateaus or benches along the Pacific Coast, north of Cape San Lucas, and has illustrated the facts by a large plate. The article does not admit of condensation, and in this place there is room at present only for this simple mention of his important observations.

6. *Mikrogeologische Studien über das kleinste Leben der Meeres-Tiefgründe aller Zonen und dessen geologischen Einfluss;* von C. G. EHRENBERG. 396 pp. 4to, with 12 plates and a map. (Abh. K. Akad. d. Wiss., Berlin, 1872.)—A review of the vast amount of facts which the author has published respecting the microscopic life of sea-bottoms over the world, together with some additional facts and plates. In connection with the many tables showing the distribution of the species, there are references to the memoirs in which they were severally described.

7. *Ostracoids or Bivalve Entomostraca.*—Professor T. RUPERT JONES has published No. X. of his papers on the Paleozoic Ostracoids in the number for June of the Annals and Magazine of Natural History; and also an article on some species, chiefly Cypridinidæ, of the Carboniferous formations, in the Quarterly Journal of the Geological Society for August, 1873.

8. *Revue de Géologie pour les Années,* 1870 *et* 1871; par M. DELESSE, Ingénieur en Chef des Mines, and M. de LAPPARENT, Ingénieur des Mines. 252 pp. 8vo. Paris. 1872. (F. Savy).—A work for all geologists.

9. *Reports on the Geological Survey of the State of Missouri,* 1855–1871. By G. C. BROADHEAD, F. B. MEEK, and B. F. SHUMARD. Published by authority of the Legislature under the direction of the Bureau of Geology and Mines. 324 pp. 8vo. Jefferson City, Mo., 1873.—This volume contains the Reports of geological work done in Missouri, by State authority, previous to the organization of last year, under Raphael Pumpelly, as geologist in charge. The several chapters treat of the local geology of the State to which they are important contributions. They include

Reports of twenty counties, six by Mr. Broadhead, three by Mr. Meek, and eleven by Mr. Shumard, some of which are illustrated by maps and sections.

10. *On Nickeliferous Sand from Frazer River;* by JAMES BLAKE, M.D.—This sand, which was obtained in the gold washings on Frazer River, has very much the appearance of small particles of iron pyrites, being of decidedly a yellowish color. Under the microscope it is found to consist of two distinct substances, one of which is evidently magnetic oxide of iron, or the common black sand of our gold deposits; the other is of a yellow color, in the form of small scales, without any well marked crystalline structure, and with the edges rounded by abrasion. The whole of the sand is strongly magnetic, so that with the exception of a few scales of gold, it contains nothing that is not taken up by the magnet. An analysis of the sand shows that it consists wholly of the oxides of nickel and iron. 0·9153 grains of the sand yielded 0·256 sesquioxide of iron, and 0·6548 oxide of nickel, which would give, supposing the iron to be in the state of magnetic oxide, 0·231 of oxide of iron; and, if we suppose an analogous oxide of nickel to exist, we should have 0·702 of the magnetic oxide of nickel; thus making 0·931 instead of 0·9153 the quantity used, the excess of 0·016 being undoubtedly due to the nickel, from the difficulty of freeing it completely from the potash with which it is precipitated.

Although I can find no mention of such a compound of nickel, either in Watts' Dictionary of Chemistry, or in Dana's Mineralogy, yet I have no doubt that the form in which the nickel exists in this sand is an oxide with the composition Ni^3O^4, analogous to the magnetic oxide of iron, Fe^3O^4, thus establishing another relation between the compounds of nickel and iron. From the large proportion of it in the sand, fully 75 per cent, it is strange that its presence has not been before noticed.—*Proc. Calif. Acad. Sci.*, v, 200.

11. *Kjerulfine.*—F. v. Kobell has given this name to a new fluophosphate from Bamle in Norway. It is described as compact, with an imperfect cleavage in two directions nearly at a right angle. The fracture is uneven and splintery; luster oily; color faint red to yellow, in thin fragments translucent. G.=3·15. H.=4–5. When heated phosphoresces with a white light. B.B. fuses easily at 3 with intumescence to a blebby enamel. Soluble in hydrochloric acid, but with greater readiness in nitric acid. With sulphuric acid, hydrofluoric acid is evolved and sulphate of lime separates from the solution. Analysis gave

$\dot{P}$	$\dot{M}g$	$\dot{C}a$	$\dot{N}a$	$\dot{K}$	Fl	$\dot{S}i$	$\dot{A}l$ $\dot{F}e$	$\dot{S}$
42·22	37·00	7·56	1·56	*tr.*	4·78	1·50	5·40	*tr.*=100·02

Excluding the silica and alumina and the oxygen of the lime and soda and averaging the analysis up to 100, von Kobell considers pure kjerulfine to consist of $\dot{P}$ 46·62, $\dot{M}g$ 40·86, Ca 5·96, Na 1·28, Fl 5·28, from which he calculates the formula to be $2\dot{M}g^3\,\dot{P}+Ca\,Fl$, in which a small portion of the calcium is replaced by sodium. This result

very nearly approaches the composition of wagnerite, but according to recent analyses of v. Kobell (Sitz. Münch. Akad., May, 1873), the latter contains

$\dot{P}$ 45·70, $\dot{M}g$ 37·18, Na 3·97, Ca 1·81, Fe 11·34,

which shows wagnerite to be richer in fluorine and soda than kjerulfine.—*Sitzung Münch. Akad.*, March, 1873.

12. *Tschermakite, a new feldspar.*—Associated with the kjerulfine above mentioned, von Kobell subsequently found another new mineral, a magnesia-soda feldspar, which he has named Tschermakite. This occurs massive, with two cleavages at an angle of 94°. The more perfect cleavage has fine striations, resembling those common in triclinic feldspars. Luster highly vitreous, almost amantine; color grayish white, translucent to semi-transparen H. =6. G. =2·64. The mineral phosphoresces with a white light on heating. B.B. fuses quietly at 3 to a translucent glass. In the closed tube gives off water. Not appreciably attacked by acids, but on boiling for a long time with hydrochloric acid the solution reacts for alumina and magnesia. Analysis gave

$\ddot{S}i$	$\dot{\ddot{A}}l$	$\dot{M}g$	$\dot{N}a$	$\dot{K}$	$\dot{H}$
66·57	15·80	8·00	6·80	*tr.*	2·70=99·87

from which, assuming the water to be basic, v. Kobell gives the ratio of oxygen for $\dot{R}$, $\dot{\ddot{R}}$, $\ddot{S}i$ 1 : 1 : 5. Named after G. Tschermak of Vienna.—*Sitzung Münch. Akad.*, Dec., 1873.

13. *Sphœralcea acerifolia* of Nuttall, a very conspicuous Malvaceous plant of the Rocky Mountain region and Oregon, has been found by Mr. E. J. Hill on an island in the Kankakee River (a tributary of the Illinois), in the northeastern part of Illinois. Unexpected as this discovery is, it is not difficult to see how the species may have got there. A good many northwestern plants occur on the shore of the southern end of Lake Michigan, evidently through water transport. Some of these may have come in recent times, although this could not be inferred simply from the fact that they have not been noticed until lately. Here is one which probably came so long ago as when Lake Michigan discharged into the Mississippi, the lower part of the Kankakee River being in the direct course of the discharge. The present plants may more probably be regarded, not as chance stragglers, but as lingering remnants indicating an ancient habitat. A. G.

14. *Necrology of Botanists.*—The list of botanists deceased during the past year is not a long one; indeed, it includes no name of sufficient mark in the Old World as to call for notice here; but the loss in the United States is heavy, unprecedented, and irreparable.

John Torrey died on the 10th of March, 1873, in the 77th year of his age. This Journal has published a short notice and a fuller biography of Dr. Torrey; the latter forming a part of the Council of the American Academy's Report, May, 1873.

William S. Sullivant, of Columbus, Ohio, died on the 30th of April last, at the age of 70 years. A biographical notice of this

eminent muscologist was duly published in this Journal,—from the same Report to the American Academy of Arts and Sciences.

Elias Durand died, at Philadelphia, August 14, 1873, in the 80th year of his age. A notice of him appeared in the September number of this Journal; and much fuller accounts of his life and services have been published in Philadelphia.

John Lewis Russell, of Salem, Mass., died on the 7th of June, in the 65th year of his age. Although he published little besides some contributions to the journals, and for several years was incapacitated by illness, he was an acute botanist, especially in the Cryptogamic department, in which his knowledge of New England plants was critical and extensive.

Henry James Clark, lately Professor in the State Agricultural College at Amherst, Mass., who died on the first of July last, at the age of 47, deserves to be enrolled in the list of botanists. Although his high reputation was won in another department, he was an excellent botanist before he became Mr. Agassiz's assistant and gave himself to zoölogical investigation: the present writer was indebted to him for more than one interesting discovery of points of structure. Prof. Clark is thought to have been the ablest microscopic investigator which this country has produced.

Isaac F. Holton, died, at Everett, Mass., January 25, at the age of 61 years. He was a graduate of Amherst College in the class of 1836, of the Union Theological Seminary, New York, and of the Medical College of the same city, where he became known to and formed a life-long friendship with Dr. Torrey. Like him he pursued both chemistry and botany; and he taught both with success, in various schools and other institutions. He was for a few years professor of the natural sciences in Middlebury College, Vermont; afterward a missionary and pastor in Illinois; whence he removed to the vicinity of Boston in the year 1865, and devoted his time mainly to journalism, always, however, keeping up his scientific activity in various fields. His most considerable publication was a thick octavo volume, published by the Harpers, in 1857, and reprinted in London, entitled "New Granada: Twenty Months in the Andes;" being principally a journal of his visit to and travels in that country a year or two previous. It is written with great spirit, and is replete with valuable information. In New Granada, Mr. Holton made a fine botanical collection of about 1800 species, the duplicates of which were distributed among some principal herbaria. Professor Holton's pursuits and tastes were too multifarious, his harmless eccentricities too pronounced, and his life too unselfish for achieving the distinction or the worldly success which he well deserved. His ambition mainly showed itself in his zeal for helping others, and in forwarding their interests without regard to his own. A. G.

15. *The Localization of the Functions in the Brain;* by Prof. FERRIER.—All are agreed that it is with the brain that we feel, and think and will, but whether there are certain parts of the brain

devoted to particular manifestations is a subject on which we have only imperfect speculations or data too insufficient for the formation of a scientific opinion. The general view is that the brain as a whole subserves mental operations, and that there are no parts specially devoted to any particular functions. This has been recently expressed by so high an authority as Professor Séquard. The idea rests chiefly on the numerous facts of disease with which we are acquainted. There are cases where extensive tracts of brain are destroyed by disease, or removed after a fracture, apparently with no result as regards the mind of the individual. Along with these facts we have others which are very curious, and which hardly seem to agree with this doctrine. One of these is that when a certain part of the brain is diseased, in Aphasia, the individual is unable to express himself in words. Other curious phenomena have been well described by Dr. Hughlings Jackson, viz: that certain tumors or pathological lesions in particular parts of the brain give rise, by the irritation which they keep up, to epileptiform convulsions of the whole of one side, or of the arm or leg or the muscles of the face; and from studying the way in which these convulsions show themselves he was able to localise very accurately, the seat of the lesion.

The great difficulty in the study of the function of the brain has been in the want of a proper method. When we study the function of a nerve, we make our experiments in two ways. In the first place, we irritate the nerve by scratching or by electricity, or by chemical action, and observe the effect; and in the second place, we cut the nerve, and observe what is lost. In regard to the brain and nervous system, the method has been almost entirely, until recently, the method of section. It has been stated by physiologists, that it is impossible to excite the brain into action by any stimulus that may be applied to it, even that of an electric current; they have, therefore, adopted the method of destroying parts of the brain. This method is liable to many fallacies. The brain is such a complex organ that to destroy one part is necessarily to destroy many other parts, and the phenomena are so complex that one cannot attribute their loss to the failure only of the parts which the physiologists have attempted to destroy.

About three years ago, two German physiologists, Fritsch and Hitzig, by passing galvanic currents through parts of the brains of dogs, obtained various movements of the limbs, such as adduction, flexion, and extension. They thus discovered an important method of research, but they did not pursue their experiments to the extent that they might have done, and perhaps did not exactly appreciate the significance of the facts at which they had arrived.

I was led to the experiments which I shall have to explain by the effects of epilepsy and of chorea, which have been explained to depend upon irritation of parts of the brain. I endeavored to imitate the effects of disease on the lower animals, and determined to adopt the plan of stimulating the parts of the brain by electricity, after the manner described by Fritsch and Hitzig.

I operated on nearly a hundred animals of all classes—fish, frogs, fowls, pigeons, rats, guinea pigs, rabbits, cats, dogs, jackals, and monkeys. The plan was to remove the skull, and keep the animal in a state of comparative insensibility by chloroform. So little was the operation felt that I have known a monkey, with one side of the skull removed, awake out of the state induced by the chloroform, and proceed to catch fleas or eat bread and butter. When the animal was exhausted I sometimes gave it a little refreshment, which it took in the midst of the experiments.

First, as to the experiments on cats, I found that on applying the electrode to a portion of the superior external convolution the animal lifted its shoulder and paw (on the opposite side to that stimulated) as if about to walk forward; stimulating other parts of the same convolution, it brought the paw suddenly back, or put out its foot as if to grasp something, or brought forward its hind leg as if about to walk, or held back its head as if astonished, or turned it on one side as if looking at something, according to the particular part stimulated. The actions produced by stimulating the various parts of the middle external convolution were a drawing up of the side of the face, a backward movement of the whiskers, a turning of the head, and a contraction of the pupil respectively. A similar treatment of the lower external convolution produced certain movements of the angles of the mouth; the animal opened the mouth widely, moved its tongue, and uttered loud cries or mewed in a lively way, sometimes starting up and lashing its tail as if in a furious rage. The stimulation of one part of this convolution caused the animal to screw up its nostrils on the same side; and, curiously enough, it is that part which gives off a nerve to the nostril of the same side.

Results much of the same character were produced by the stimulation of the corresponding or homologous parts of the rat, the rabbit, and the monkey. Acting upon the anterior part of the ascending frontal convolution, the monkey was made to put forward its hand as if about to grasp. Stimulation of other portions acted upon the biceps, and produced a flexing of the fore-arm, or upon the zygomatic muscles. The part that appeared to be connected with the opening of the mouth and the movement of the tongue was homologous with the part affected in man in cases of Aphasia. Stimulation of the middle temporo-sphenoidal convolution produced no results; but the lower temporo-sphenoidal, when acted upon, caused the monkey to shut its nostrils. No result was obtained in connection with the occipital lobes.

These experiments have an important bearing upon the diagnosis in certain kinds of cerebral disease, and the exact localization of the parts affected. I was able to produce epileptic convulsions of all kinds in the animals experimented upon, as well as phenomena resembling those of chorea or St. Vitus's dance. The experiments are also important anatomically, as indicating points of great significance in reference to the homology of the brain in lower animals and in man, and likewise served to explain some curious

forms of expression common to man and the lower animals. The common tendency, when any strong exertion is made with the right hand, to retract the angle of the mouth and open the mouth on the same side, had been stated by Oken, in his Naturgeschichte, to be due to the homology between the upper limbs and the upper jaw; the true explanation being that the movements of the fist and of the mouth are in such close relation to each other that when one is made to act powerfully the impression diffuses itself to the neighboring part of the brain and the two act together.

The experiments have likewise a physiological significance. There is reason to believe that when the different parts of the brain are stimulated, ideas are excited in the animals experimented upon, but it is difficult to say what the ideas are. There is, no doubt, a close relation between certain muscular movements and certain ideas which may prove capable of explanation. This is supported by the phenomena of epileptic insanity. The most important guide on the psychological aspect of the question is the disease known as Aphasia. The part of the brain which is the seat of the memory of words is that which governs the movements of the mouth and the tongue. In Aphasia the disease is generally on the left side of the brain, in the posterior part of the inferior frontal convolution, and it is generally associated with paralysis of the right hand, and the reason might be supposed to be that the part of the brain affected is nearly related to the part governing the movements of the right hand.

It is essential to remember that the movements of the mouth are governed bi-laterally from each hemisphere. The brain is symmetrical, and I hold it to be a mistake to suppose that the faculty of speech is localized on the left side of the brain. The reason why an individual loses his speech when the left side of the brain is diseased is simply this. Most persons are right-handed, and therefore left-brained, the left side of the brain governing the right side of the body. Men naturally seize a thing with the right hand; they naturally therefore use rather the left side of the brain than the right, and when there is disease, there the individual feels like one who has suddenly lost the use of his right arm.

I may, finally, briefly allude to the results of stimulating the different ganglia. Stimulation of the corpora striata causes the limbs to be flexed; the optic thalami produces no result; the corpora quadrigemina produce, when the anterior tubercles are acted upon, an intense dilatation of the pupil, and a tendency to draw back the head and extend the limbs as in opisthotonos; while the stimulation of the posterior tubercles leads to the production of all kinds of noises. By stimulating the cerebellum various movements of the eye balls are produced.

In the discussion which ensued, Dr. Geo. Harley alluded to the effect of mental emotion on the bodily functions, and the possibility of producing disease by simply acting on the nervous system. Referring to phrenology, he said it was one thing to localize function in the interior of the brain, and quite another to specify func-

tions by manipulating the external cranium; and he quoted a saying of Flourens with reference to phrenology: "Les hommes qui la pratiquent sont des charlatans, et les hommes qui la croient sont des imbeciles."

Dr. Carpenter remarked that the great work of the brain is done in the cortical substance, and in Dr. Ferrier's experiments, the first effect of the stimulus is upon that particular substance, producing an intensification of the circulation through it; being in that respect different from the ordinary stimulation of a nerve which acts upon the fibrous substance of the medullary matter of the brain. He had long since expressed his disbelief in phrenology, which maintained that the animal functions were placed at the back of the head, and the intellectual at the front. Dr. Ferrier's experiments tended to show that the real seat of the intellectual functions was in the posterior part of the brain.

Dr. Brunton, however, alluded to the faculty of will and of self-restraint as distinguishing man from the lower animals, and said that this was probably situated in the *anterior* part of the brain. It was noticeable that criminals, who were deficient in that faculty, possessed only a small portion of brain in front of the head.

Prof. Burdon Sanderson said that the stimulus in Dr. Ferrier's experiments was, contrary to Dr. Carpenter's supposition, exactly like the ordinary excitation of a nerve, and that the effect was produced in an extremely short space of time.—*Rep. Brit. Assoc.*, 1873, *Nature*, *Oct.* 2.

III. Astronomy.

1. *Discovery of a new Planet;* by C. H. F. Peters. From a communication to one of the editors, dated Litchfield Observatory of Hamilton College, Clinton, N. Y., Feb. 19, 1873.—I take pleasure in communicating the discovery last night of a small planet, not among the known ones, as it seems. I succeeded in getting a full set of ring-micrometer comparisons, but, the sky between 3 and 4 o'clock clouding up, I could not accomplish the determination of the comparison star except approximately. The following place of the planet is near within a minute:

1874, Feb. 18, $14^h\ 30^m$ m. t. $\alpha\,(135) = 11^h\ 19^m\ 43^s$; $\delta\,(135) = +\ 4°\ 25'$.

Its motion seems not much inclined to the parallel. The magnitude I estimated at about 11·2.

2. *Astronomical Society of London.*—The Gold Medal of this Society has been awarded by its Council to Prof. Simon Newcomb, for his tables of Neptune and Uranus and his other mathematical works.

3. *Academy of Sciences at Paris.*—In the section of *Astronomy*, of the French Academy, Dr. Huggins has been elected to replace M. Petit, and Mr. Newcomb, to replace M. Valz.

IV. Miscellaneous Scientific Intelligence.

1. *Direction of Frost-striations in Mud;* Rev. F. R. Goulding. (Extracts from a communication dated Roswell, Cobb Co., Georgia.)—I ask the privilege of calling attention to a natural phenomenon which has long enlisted my interest and that of a few others, but which remains, so far as known, without explanation. It is that of slight but plainly marked striations of the soil after a freezing, looking as if a very light harrow had been drawn over it from northwest to southeast, leaving irregular furrows, varying from half an inch to an inch and a half, in depth, and from center to center.

My attention was first drawn to it in 1854, in upper Georgia, during and after the thawing of an extensive and severe "black frost."

After residing for ten years in a region where there were no *black frosts*, and of course no striations, I returned to the mountains of Georgia, and was soon reminded of former observations, by seeing the soil of my garden very deeply marked, the same way as before, during, or rather toward the close of a hard freezing. This place is about forty miles distant from the other, and the soil wholly different, that being limestone and this granite. These striæ invariably run from northwest to southeast, and this is so in shaded as in sunny places, and whether the wind at the time blew, or whether the air was still. They begin to appear before the frozen surface has thawed. Further, the direction is at right angles to the stratification of the country, the outcroppings of the rocks being here in a line from northeast to southwest. If this coincidence be connected with the cause of the striations, it is in some way beyond the ken of us the observers. The writer would be glad to receive any facts that will prove whether any uniformity of direction is observable elsewhere, and that will, if so, lead to its explanation.

2. *The New Chemistry;* by Josiah P. Cooke, Jr. 326 pp. 12mo. New York. *The International Scientific Series.* (D. Appleton and Company).—Prof. Cooke, in this volume, presents his readers with a lucid and logical discussion of the principles of Chemical Philosophy in a series of thirteen lectures: 1. Molecules and Avogadro's law; 2. The molecular condition of the three states of matter—the gas, the liquid, and the solid; 3. How molecules are weighed; 4. Chemical composition—analysis and synthesis—the atomic theory; 5. Elementary substances and combining proportions; 6. Atomic weights and chemical symbols; 7. Chemical reactions; 8. Chemical changes classified; 9. The theory of combustion; 10. Gunpowder and Nitro-glycerine; 11. Quantivalence and metathesis—alkalies and acids; 12. Electrochemical theory; 13. Isomerism, and synthesis of organic compounds. These lectures were delivered before the Lowell Institute, in Boston, in the autumn of 1872, and the author, in presenting his subject in this volume, has preserved the lecture style, so well adapted to convey clearly to the non-professional, but intelligent, auditor, clear notions of abstract ideas. Prof. Cooke's style is

always attractive from its clearness, precision and polish, and any cultivated person, whether previously acquainted with chemistry or not, can read this discussion of chemical philosophy with both pleasure and profit. It is needless to add that the subject is discussed as its title demands, in the terms of the new chemistry.

3. *Annual Report upon the Geographical and Geological Surveys and Explorations west of the* 100*th Meridian, in Nevada, Utah, Colorado, New Mexico and Arizona;* by GEORGE M. WHEELER, First Lieut. of Engineers, U. S. A. Being Appendix EE of the Annual Report of the Chief of Engineers for 1873. 12 pp. 8vo, with a Map.—From this brief report of Lieut. Wheeler we learn that, while the work in the field will be continued, it is proposed that arrangements should go into effect at once for the publication of the results thus far obtained. The results are of great value, and the publication of them will take six quarto volumes, and a folio atlas 19 inches by 24. Vol. 1 will be occupied with a general account of the expeditions of 1871 and 1872, describing the regions traversed, its industries, the native tribes. The *second* will be geographical; the *third*, meteorological; the *fourth*, geological, it consisting of the finished report of the geological work for the same years, and occupying about 225 pages; the *fifth* paleontological, to be illustrated by numerous plates of new Vertebrate and Invertebrate fossils from the Rocky mountain region, obtained in the years 1871, 1872 and 1873; the *sixth* Natural History. The Geological volume, vol. 4, will contain reports from Messrs. Gilbert, Marvine and Howell.

4. *The Cincinnati Quarterly Journal of Science.* Editor and Proprietor, S. A. MILLER. Vol. I, No. 1, January, 1874. 96 pp. 8vo. Cincinnati, Ohio. ($3.00 per year.)—This first number opens well the new Cincinnati Quarterly Journal of Science. The region from which it is issued is one of unusual interest for its geology, paleontology and natural history, and is a great commercial and educational center for the land, and the Journal should hence be successful. In paleontology, the author occupies several pages of the number with short critical articles; there is also a paper on New Brachiopods by U. P. James, and a translation is given of observations on Fossil Sponges in Rœmer's work on the Silurian Fauna of West Tennessee, besides a reproduction of H. B. Hall's Memoir on Fossil Sponges from the London Geological Magazine. There are also other important papers, most of them cited, which have a more popular character. The Journal is well printed, and has our best wishes for its permanence and wide circulation.

5. *Half Hour Recreations in Natural History; Half Hours with Insects.*—Part V. *Insects of the Garden*, their habits, etc.; by A. S. PACKARD, Jr. 32 pp. 8vo. Boston (Estes & Laureat).—Professor Packard is one of the best of American writers on insects, and has produced here a chapter that all will read with interest. It is the first of twelve parts on the Insects of Gardens.

The Stone Age, Past and Present, by E. B. Taylor, and Theory of a Nervous Ether, by Dr. Richardson, make No. 9 of Estes & Laureat's "Half Hour Recreations in Popular Science."

APPENDIX.

ART. XXVIII.—*Notice of New Equine Mammals from the Tertiary Formation;* by O. C. MARSH.

THE explorations of the Yale College party in the Tertiary deposits of the West, during the past season, brought to light many equine remains; some of which prove to be new, and others throw considerable light on the forms already made known by previous investigations. In the present communication some of the more important results obtained are briefly presented, those relating to the genealogy of the modern horse being of special interest.

Orohippus Marsh.

This Journal, iv, p. 207; v, p. 407.

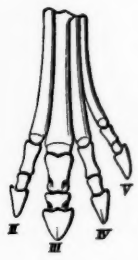
The equine mammals of the American Eocene are at present represented by three species of the genus *Orohippus*, the main characters of which have already been pointed out by the writer. Additional material clears up several doubtful points in its structure. This genus is nearly related to *Anchitherium*, but differs especially in having four functional digits in the manus, and in the absence of an antorbital fossa. The orbit is not enclosed behind. The dentition is very similar to that of *Anchitherium*, but the first upper premolar is proportionally larger, and the succeeding premolars are smaller. The median posterior tubercle of the molars is wanting. The first lower premolar was small, and the rest of the lower molar series closely resemble those in *Anchitherium*. There is long distema. The canine is large, and near the incisors. The crowns of the grinders are very short, and without cement. The dental formula is as follows:

$$\text{Incisors } \frac{3}{3}, \text{ canines } \frac{1}{1}, \text{ premolars } \frac{4}{4}, \text{ molars } \frac{3}{3}.$$

The skeleton of *Orohippus*, in its general features, is decidedly equine, and this is particularly manifest in the limbs. The scapula has a prominent acromial process, which is compressed and decurved, as in some of the carnivores. The humerus is short and stout. Its head is large, and the bicipital groove

narrow and deep. The great tuberosity is elevated, and compressed. The distal end of the humerus is small. The radius and ulna are distinct. The latter is larger than in *Anchitherium*, and entire throughout its whole length. The carpal bones are eight in number, and somewhat similar to those of the Tapir, although the trapezium is proportionally much smaller.

All the digits of the manus, except the first, are well developed, as shown in the accompanying figure of the left forefoot of *Orohippus agilis* Marsh. The third digit is the largest, and its close resemblance to that of the horse is clearly marked. The terminal phalanx, or coffin bone, has a shallow median groove in front, as in many species of this group in the later Tertiary. The fourth digit exceeds the second in size, and the fifth is much the shortest of all. Its metacarpal bone is considerably curved outward. In the pes of this genus, there are but three digits. The fourth metatarsal is much larger than the second. The astragalus has its neck more elongated than in *Anchitherium*, and the face for the cuboid is small. The tibia and fibula are distinct. The cervical vertebræ of *Orohippus* are rather short, and moderately opisthocœlous.



Orohippus major, sp. nov.

The largest species of this genus is indicated by part of an upper jaw with three molars, and the greater portion of a lower jaw with teeth pertaining to another individual. In the former specimen, the intermediate lobes of the molars are less developed than in the species already described, while the antero-posterior buttress is more elevated. The lower jaw is stout, and there is a strong basal ridge on the outer face of the lower molars.

Measurements.

Space occupied by three upper true molars,	24·mm.
Antero-posterior diameter of last upper molar,	8·5
Transverse diameter,	10·
Antero-posterior diameter of penultimate upper molar,	8·5
Transverse diameter,	11·
Extent of four posterior teeth of lower jaw,	33·5
Antero-posterior diameter of last lower molar,	10·5
Transverse diameter,	5·
Antero-posterior diameter of last lower premolar,	7·5
Depth of jaw below middle of this tooth,	14·

This species was about as large as a fox. The remains of it at present known are from the Eocene of Wyoming.

The animals of this genus constitute a distinct family that may be called *Orohippidæ*. The other known species are as follows:

Orohippus gracilis Marsh.

(*Anchitherium gracile* Marsh;) this Journal, ii, p. 38, 1871.

Orohippus pumilus Marsh.

This Journal, iv, p. 207, 1872. (? *Helotherium procyoninum* Cope, Proc Am. Phil. Soc., xii, p. 466, Feb., 1873.)

Orohippus agilis Marsh.

This Journal, v, p. 407, 1873.

All the animals of this genus now known were quite diminutive, the largest hardly exceeding a fox in size. They are all from the Eocene of Wyoming and Utah.

Miohippus annectens, gen. et sp. nov.

The present genus represents an intermediate form between *Orohippus* and *Anchitherium*. It differs from the former in having but three digits in the manus, and from the latter in the absence of an antorbital fossa, and in the more complete separation of the intermediate lobes of the upper molars. Its dental formula is apparently the same as *Orohippus*. The incisor teeth are small, and the canines large, those below being close to the incisors. The first upper premolar is of moderate size, and the second larger than the last true molar. In the upper molars, the basal ridge rises into a tubercle near the middle of the anterior border. The premaxillaries are slender. The radius and ulna are free, or only loosely united, but the fibula is fused to the tibia at its distal end. The second and third cuneiform bones are distinct. There are three digits in the manus, and three in the pes, all of which reached the ground. They appear to have been more nearly of equal size than in *Anchitherium*.

In the present species the orbit is large, and its anterior margin is directly above the front of the last upper molar. The first upper premolar had two fangs. The enamel of all the teeth preserved is quite smooth. The upper premolars and most of the molars have a prominent compressed tubercle between the inner cusps, but no inner basal ridge. This species differs widely from any hitherto described, with the possible exception of *Anchitherium Condoni* Leidy * The latter species was founded on an imperfect upper molar tooth, which probably belongs to the genus *Miohippus* The enamel of this molar is quite rugose, the small cusp behind the posterior crest is parallel with the posterior basal ridge, and the inner tubercle between the transverse crests is entirely wanting. This tooth

* Proc. Acad. Nat. Sci. Philadelphia, 1870, p. 112.

is also proportionally broader than the corresponding teeth of the present species, and hence the two must be regarded as distinct.

Measurements.

Space occupied by four upper premolars,	61· mm.
Extent of three upper true molars,	46·
Antero-posterior diameter of first upper premolar,	13·5
Antero-posterior diameter of second upper premolar,	19·
Transverse diameter,	18·
Antero-posterior diameter of last upper molar,	14·
Transverse diameter,	19·5
Length of calcaneum,	68·
Length of astragalus,	32·
Antero-posterior diameter of tibia at distal end,	26·
Transverse diameter,	33·

All the known remains of this species are from the Miocene of Oregon. They indicate an animal somewhat exceeding a sheep in size, and with longer limbs.

Anchitherium anceps, sp. nov.

The Miocene deposits of Oregon contain another species of solipeds, smaller than the one just described, and apparently belonging to the genus *Anchitherium*. The skull has a large antorbital fossa, and the molar teeth agree essentially with those of that genus. The limbs, so far as known, were also similar. The first upper premolar has two fangs, and is well developed. The infra-orbital foramen is above the center of the third premolar. The present species most nearly resembles *Anchitherium Bairdi* Leidy, from the Miocene east of the Rocky Mountains. It differs, however, aside from the larger size, in the following particulars: the skull is depressed between the orbits; the molar teeth extend farther back below the orbit; the external cusps of the upper molars have their buttresses much stouter, and the concavities between them divided by more prominent vertical ridges.

Measurements.

Space occupied by four upper premolars,	47·5 mm.
Antero-posterior diameter of first upper premolar,	9·
Antero-posterior diameter of second upper premolar,	13·
Transverse diameter,	13·
Antero-posterior of last upper premolar,	13·
Transverse diameter,	15·5
Antero-posterior diameter of last lower molar,	17·
Transverse diameter,	8·
Extent of upper molar series (second specimen),	82·
Extent of three upper true molars,	37·

The remains of this species indicate an animal about as large as a sheep. The specimens on which the above description is

mainly based, were presented to Yale College Museum by the Rev. Thomas Condon, of Oregon.

Anchitherium celer, sp. nov.

The smallest species of *Anchitherium* from the American Tertiary is indicated by some fragmentary remains in the Yale Museum, from the Miocene of Nebraska. These fossils pertain to a fully adult animal, which was about two-thirds the size of *Anchitherium Bairdi*. The orbit is placed well forward. The ridge below it is especially prominent, and much elevated above the molar teeth. The crowns of the latter are remarkably short. The four posterior molars have their inner margins on a line. The last upper molar is quite small.

Measurements.

Space occupied by last four upper molars,	37· mm.
Extent of three upper true molars,	27·
Antero-posterior diameter of last upper premolar,	10·
Transverse diameter,	13·
Antero-posterior diameter of last upper molar,	8·5
Transverse diameter,	12·
Distance of lower margin of orbit above last upper molar,	20·

The type specimen of the species was presented to Yale College Museum by Capt. W. A. Jones, of the U. S. Engineers.

Protohippus parvulus Marsh.

(*Equus parvulus* Marsh, this Journal, xlvi. p. 374, 1868.)

A reëxamination of the remains of this species originally described, and of the other fossils found with them, clearly indicates, as at first suspected, that this diminutive animal was not a true *Equus*, and there can now be but little doubt that it belongs in the genus *Protohippus* of Leidy, as at present understood. With the limb bones preserved, an upper molar tooth was found, which doubtless pertained to the same animal, although it is rather larger in proportion than the teeth of some allied species. The crown of this tooth is very short, and the arrangement of the enamel particularly simple. The inner lakes have no folds, and agree in form with those of *Protohippus* (*Merychippus*) *insignis* Leidy. The anterior lake, at its inner posterior angle, is connected by a narrow outlet with the main transverse valley. The inner anterior column is a broad oval in outline, and is connected with the antero-median column. This molar is from near the middle of the series, and measures $15^{mm.}$ antero-posterior diameter. Other fragmentary teeth indicate that the incisors were very small, and the canines large.

The bones of the feet preserved, which may with considerable certainty be referred to the same individual, imply that the manus and pes had the lateral digits developed, as in *Hipparion*.

The known remains of this species indicate an animal about two and a half feet in height. The specimens described are from the Pliocene beds at Antelope Station, Nebraska. Other remains of the same species were found by the writer, last year, on the Niobrara River, in the same geological horizon.

Pliohippus pernix, gen. et sp. nov.

A new genus of solipeds, allied to *Equus*, is well represented in the Yale Museum by two partial skeletons, with the more important portions preserved, and by numerous fragmentary remains. This genus closely resembles *Protohippus* Leidy in its dentition, but differs in the absence of lateral digits, which are only represented by slender splint bones. From the true *Equus*, the present genus may be distinguished by the presence of a large antorbital fossa; by the functional first upper premolar; and by a different composition of the crowns of the upper molars. The dental formula of *Pliohippus* is as follows:

$$\text{Incisors } \frac{3}{3}, \text{ canines } \frac{1}{1}, \text{ premolars } \frac{4}{3}, \text{ molars } \frac{3}{3}.$$

The incisors have the characteristic pit of the modern horse. The molars have short crowns, with distinct fangs. The skull is comparatively short, and the orbit is closed behind. The ulna is not entire, and its extremities are ankylosed to the radius. The distal end of the fibula has coalesced with the tibia. On the radial side of the carpus, there is a small ossicle which appears to represent the trapezium. On the opposite side, attached to the unciform, there was a rudiment of the fifth metacarpal.

The present species was about the size of the ass. The skull is larger, and has a deep irregular fossa in front of the orbit. The molar teeth have very short crowns, and long fangs. The folds of the enamel are very simple, and there are none in the inner lobes. The limbs were slender, and more elongated than in the ass. The ungual phalanges are broader, and slightly cleft at their extremities. The femur has the fossa above its outer condyle unusually deep. The cuboid facet on the astragalus is larger than in most equines.

Measurements.

Extent of four upper premolars,	88· mm.
Antero-posterior diameter of first upper premolar,	13·
Antero-posterior diameter of second premolar,	31·
Extent of three upper true molars,	68·
Antero-posterior diameter of last upper molar,	28·
Extent of lower molar series,	146·
Extent of last three lower molars,	72.
Length of radius,	253·

Width of proximal end,	49·	mm.
Width of articulation of distal end,	40·	
Length of third metacarpal,	189·	
Length of first phalanx of third metacarpal,	55·	
Length of second phalanx,	25·	
Length of third phalanx,	38·	
Width of third phalanx,	50·	
Length of calcaneum,	77·	
Length of astragalus,	41·	
Length of third metatarsal,	208·	

The specimen here described was exhumed by the writer, in June last, from the Pliocene sands of the Niobrara River, Nebraska.

Pliohippus robustus, sp. nov.

A second species of the genus *Pliohippus* is indicated by part of a skeleton with portions of the skull and teeth of one individual, and apparently by fragments of others. This species was nearly the same size as that last described, but the limbs were shorter and stouter. The first upper premolar is much larger, and the upper molars are longer, and much curved. The crowns of these teeth have a very similar arrangement of the enamel, but the folds are more complex.

Measurements.

Extent of four upper premolars,	98·	mm.
Antero-posterior diameter of first upper premolar,	18·	
Antero-posterior diameter of second premolar,	29·	
Extent of three upper true molars,	73·	
Transverse diameter of humerus at distal end,	54·	
Transverse diameter of radius at proximal end,	50·	
Transverse diameter of distal end,	50·	
Length of third metacarpal,	178·	
Width of proximal end,	33·	
Width of distal articular face,	29·	
Length of first phalanx of third metacarpal,	54·	
Length of second phalanx,	30·	
Length of third phalanx,	36·	

The known remains of this species were found by the writer, last summer, in the Pliocene strata of the Niobrara River.

Protohippus avus, sp. nov.

A number of teeth from the Pliocene beds of Oregon indicate a well marked species, which may provisionally be placed in the genus *Protohippus*, although they differ so widely from those already described that additional remains will probably prove them to be generically distinct. The most of these specimens are apparently all from one individual, and consist of a nearly complete series of upper and lower molars, and one

incisor. The molar teeth have very short crowns, and are inserted by distinct fangs. The enamel is covered with a thick coat of cement. The molars are considerably worn, and the pattern of the enamel thus produced nearly resembles that in the corresponding teeth of *Anchitherium*, with which the present teeth agree, also, in form and arrangement. The main peculiarity of the upper molars is, that in all of them the anterior lake opens into the transverse valley, while the outer lake is distinct, and much contracted. The outer concavities of the external lobes are without any median elevation. The posterior inner cone is larger than the one in front. All the lower molars have an outer basal ridge. The middle teeth are the largest of the series. The second premolar resembles in form the same tooth in *Anchitherium*, but the anterior buttress is less distinct. There are six lower molars, the last premolar being the largest of the series. The first premolar had its anterior lobe unworn, and much elevated above the level of the grinding surface. The fore and aft diameter of the lower molars is unusually short. The enamel of these teeth is strongly rugose, more so than that of the upper molars.

Measurements.

Space occupied by six upper molars,	110·mm.
Space occupied by three upper premolars,	57·
Antero-posterior diameter of second upper premolar,	23·
Transverse diameter,	22·
Antero-posterior diameter of last upper molar,	17·
Transverse diameter,	22·
Extent of three lower premolars,	57·
Antero-posterior diameter of first lower premolar,	20 5
Transverse diameter,	15·
Antero-posterior diameter of first lower true molar,	18·
Transverse diameter,	16·

For the type specimen of the species, I am indebted to Rev. Thomas Condon, of Oregon, who first explored the Pliocene strata of that State.

Anchippus brevidens, sp. nov.

The genus *Anchippus* Leidy was founded on a single upper molar tooth from strata, in Texas, supposed to be Miocene.* Several teeth obtained by the Yale party in the Pliocene of Oregon clearly belong to the same genus, but indicate a distinct species. These teeth agree in the general structure of their crowns with the type of *Anchippus Texanus*, but the antero-median lobe is placed further forward, and hence its worn surface is not in the same line with that of the antero-internal lobe. The posterior crescentoid tubercle, also, is isolated, and

* Proc. Acad. Nat. Sciences, Philadelphia, 1868, p. 231.

wears into an ear-shaped lobe, enclosing a pit filled with cement. The crowns of these molars are unusually short, even when unworn. They all have distinct fangs, and their enamel is covered with cement. The outer lobes have only a faint indication of a median ridge on their concave faces. The buttresses that enclose these faces are prominent.

Measurements.

Antero-posterior diameter of first upper true molar,	17·5^{mm}.
Transverse diameter,	22·
Antero-posterior diameter of last upper molar,	17·
Transverse diameter,	21·5
Height of unworn crown of last upper molar,	15·

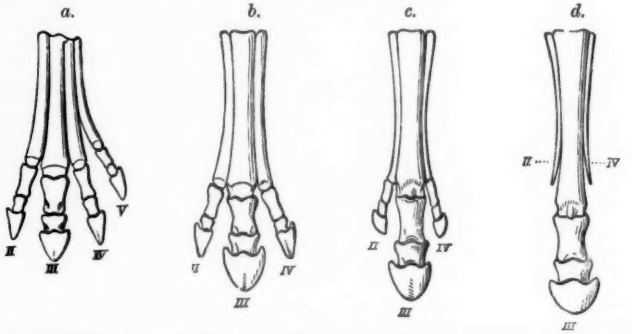
The specimens here described indicate that the genera *Anchippus* and *Hyphippus*, established by Dr. Leidy, are nearly related, and will probably prove to be identical.

The large number of equine mammals now known from the Tertiary deposits of this country, and their regular distribution through the subdivisions of this formation, afford a good opportunity to ascertain the probable lineal descent of the modern horse. The American representative of the latter is the extinct *Equus fraternus* Leidy, a species almost, if not entirely, identical with the old world *Equus caballus* Linn., to which our recent horse belongs. Huxley has traced successfully the later genealogy of the horse through European extinct forms,* but the line in America was probably a more direct one, and the record is more complete. Taking, then, as the extremes of a series, *Orohippus agilis* Marsh, from the Eocene, and *Equus fraternus* Leidy, from the Quaternary, intermediate forms may be intercalated with considerable certainty from the thirty or more well marked species that lived in the intervening periods. The natural line of descent would seem to be through the following genera:— *Orohippus*, of the Eocene; *Miohippus* and *Anchitherium*, of the Miocene; *Anchippus*, *Hipparion*, *Protohippus*, and *Pliohippus*, of the Pliocene: and *Equus*, Quaternary and recent.

The most marked changes undergone by the successive equine genera are as follows: 1st, increase in size; 2nd, increase in speed, through concentration of limb bones; 3d, elongation of head and neck, and modifications of skull. The increase in size is remarkable. The Eocene *Orohippus* was about the size of a fox. *Miohippus* and *Anchitherium*, from the Miocene, were about as large as a sheep. *Hipparion* and *Pliohippus*, of the Pliocene, equalled the ass in height: while the size of the Quaternary *Equus* was fully up to that of the modern horse.

* Anniversary Address, Geological Society of London, 1870.

The increase of speed was equally marked, and was a direct result of the gradual modification of the limbs. The latter were slowly concentrated, by the reduction of their lateral elements and enlargement of the axial one, until the force exerted by each limb came to act directly through its axis, in the line of motion. This concentration is well seen, e. g., in the fore limb. There was, 1st, a change in the scapula and humerus, especially in the latter, which facilitated motion in one line only; 2nd, an expansion of the radius, and reduction of the ulna, until the former alone remained entire, and effective; 3rd, a shortening of all the carpal bones, and enlargement of the median ones, ensuring a firmer wrist; 4th, an increase in size of the third digit, at the expense of those on each side, until the former alone supported the limb. The latter change is clearly shown in the following diagram, which represents the fore feet of four typical genera in the equine series, taken in succession from each of the geological periods in which this group of mammals is known to have lived:



a. Orohippus (Eocene); *b. Miohippus* (Miocene); *c. Hipparion* (Pliocene); *d. Equus* (Quaternary).

The ancient *Orohippus* had all four digits of the manus well developed. In *Miohippus*, of the next period, the fifth toe has disappeared, or is only represented by a rudiment, and the limb is supported by the second, third, and fourth, the middle one being the largest. *Hipparion*, of the later Tertiary, still has three digits, but the third is much stouter, and the outer ones have ceased to be of use, as they do not touch the ground. In *Equus*, the last of the series, the lateral hoofs are gone, and the digits themselves are represented only by the rudimentary splint bones.* The middle, or third, digit supports the limb, and its size has increased accordingly. The corresponding

* The modern horse occasionally has one of the ancestral hooflets developed, usually on the fore foot.

changes in the posterior limb of these genera are very similar, but not so manifest, as the oldest type (*Orohippus*) had but three toes behind. An earlier ancestor of the group, perhaps in the lowest Eocene, probably had four toes on this foot, and five in front. Such a predecessor is as clearly indicated by the feet of *Orohippus*, as the latter is by its Miocene relative. A still older ancestor, possibly in the Cretaceous, doubtless had five toes in each foot, the typical number in mammals. This reduction in the number of toes may, perhaps, have been due to elevation of the region inhabited, which gradually led the animals to live on higher ground, instead of the soft lowlands where a polydactyl foot would be an advantage.

The gradual elongation of the head and neck, which took place in the successive genera of this group during the Tertiary period, was a less fundamental change than that which resulted in the reduction of the limbs. The process may be said to have already began in *Orohippus*, if we compare that form with other most nearly allied mammals. The diastema, or "place for the bit," was well developed in both jaws even then, but increased materially in succeeding genera. The number of the teeth remained the same until the Pliocene, when the front lower premolar was lost, and subsequently the corresponding upper tooth ceased to be functionally developed. The next upper premolar, which in *Orohippus* was the smallest of the six posterior teeth, rapidly increased in size, and soon became, as in the horse, the largest of the series. The grinding teeth at first had very short crowns, without cement, and were inserted by distinct roots. In Pliocene species, the molars became longer, and were more or less coated with cement. The modern horse has extremely long grinders, without true roots, and covered with a thick external layer of cement. The canine teeth were very large in *Orohippus*, and in this genus, as well as those from the Middle Tertiary, appear to have been well developed in both sexes. In later forms, these teeth declined in size, especially as the changes in the limbs afforded other facilities for defence, or escape from danger. The incisors in the early forms were small, and without the characteristic pit of the modern horse. In the genera from the American Eocene and Miocene, the orbit was not enclosed behind by an entire bridge of bone, and this first makes its appearance in this country in Pliocene forms. The depression in front of the orbit, so characteristic of *Anchitherium* and some of the Pliocene genera, is, strange to say, not seen in *Orohippus*, or the later *Miohippus*, and is wanting, likewise, in existing horses. It is an interesting fact that the peculiarly equine features acquired by *Orohippus* are retained persistently throughout the entire series of succeeding forms. Such, e. g., is the form of symphysial part of the lower jaw,

and also the characteristic astragalus, with its narrow, oblique, superior ridges, and its small articular facet for the cuboid.

Such is, in brief, a general outline of the more marked changes that seem to have produced in America the highly specialized modern *Equus* from his diminutive, four-toed predecessor, the Eocene *Orohippus*. The line of descent appears to have been direct, and the remains now known supply every important intermediate form. It is, of course, impossible to say with certainty through which of the three-toed genera of the Pliocene that lived together, the succession came. It is not impossible that the later species, which appear generically identical, are the descendants of more distinct Pliocene types, as the persistent tendency in all the earlier forms was in the same direction. Considering the remarkable development of the group throughout the entire Tertiary period, and its existence even later, it seems very strange that none of the species should have survived, and that we are indebted for our present horse to the old world.

Yale College, New Haven, Feb. 20th, 1874.